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The economics and politics of foreign aid and domestic revenue

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Abstract: The main argument of this paper is that there is considerable heterogeneity in the way aid can shape tax performance in developing countries: through behavioural effects, donor conditionality, recipient policy reform and technical assistance; and these effects are country-specific. We investigate these effects by applying the dynamic Common Correlated Effects Mean Group estimator to a dataset comprising 84 developing countries from 1980 to 2013. The following results ensued: aid and taxes comprise an equilibrium relation, with a positive long-run association between aid and taxes; causality runs from aid to taxes, suggesting that on average, changes in aid induce permanent changes in taxes.

Keywords: aid, taxation, tax reform, cointegration, common factor models

JEL classification: C23, E62, F35, O23

All the tables are based on OECD/DAC and ICTD/UNU-WIDER GRD data.

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1 Introduction

Increasing tax revenue, one of the facets of domestic revenue mobilization (DRM hereafter), is essential for developing countries given the increased financial need to meet sustainable development targets. This is particularly salient for aid recipients, as traditional donor assistance is unlikely to increase sufficiently to meet future development finance requirements. Increasing tax revenue is a challenge for most low-income countries because: (a) tax bases are small and narrow; (b) large informal and agricultural (subsistence) sectors; (c) natural resource dependence, and volatility of resource tax revenues; (d) weak tax administrations; (e) the political environment and the influence of interest groups (for example, Besley and Persson, 2014; Mascagni, Moore and McCluskey, 2014; Junquera-Varela, Verhoeven, Shukla, Haven, Awasthi, and Moreno-Dodson, 2017). These challenges allow foreign aid to have direct effects on DRM, not least because aid and taxes are alternative sources of revenue, with the choice between them dependent on domestic political economy factors (Morrissey, 2015). This has bred a huge strand of literature, rather tenuous, exploring the impact of aid on tax effort (measured as the tax/GDP or the revenue/GDP ratio) in developing countries.

The main aim of this paper is to contribute to the aid-tax literature by examining, empirically, the long-run equilibrium relationship between foreign aid (and its components) and tax ratios in 84 developing countries over the period 1980 to 2013; employing a different econometric method than in the existing literature. The originality of our analysis is borne from the use of novel panel time-series techniques which have a huge bearing on how the relationship between aid and tax has been modelled in the past; and our empirical approach diverges from existing studies in three ways: first, we test for a positive long-run relationship between aid and taxes, and allow for cross-country heterogeneity in the long-run relationship across countries. Second, we employ a flexible dynamic empirical strategy which permits us to distinguish long-run (equilibrium) from short-run behaviour in the aid-tax relationship. This allows us to estimate long-run and short-run parameters in the model, test for the existence of a cointegrating (long-run equilibrium) relationship between aid and taxes; while addressing simultaneity and endogeneity using recently developed tests for the direction of long-run causality. Third, we account for unobserved recipient heterogeneity in a more flexible way by employing the common factor approach (Kapetanios, Pesaran and Yamagata, 2011; Pesaran, 2006). The common factor approach allows for cross-country heterogeneity in the relationship between aid and taxes, as well as cross-section correlations in the data; *created* by global shocks (for example, the oil price shocks of the 1970s or the recent financial crisis) that affect countries to varying degrees, and *represented* by unobserved common factors.

There are at least four ways in which aid may affect taxes (and DRM in general). First, aid can have behavioural effects on taxation: because aid provides revenue, it can substitute for efforts to raise tax revenue (governments will decide whether to expend effort in collecting taxes). The choice between tax and aid will depend on the political costs of taxes (increasing taxes is unpopular) and aid (increased dependency and lack of autonomy), and how these costs offset each other (Morrissey, 2015). Second, technical assistance (transfer of knowledge and capacity building) associated with aid also influence taxes. Third, donor conditions (for example, trade liberalization and revenue conditionality in donor-supported programs) and recipient policies associated with aid (for example, creating autonomous revenue authorities), as distinct from the amount of aid, affect tax revenue. Fourth, the nature of donor-recipient relationships, reflected by the stability and predictability of aid flows, would impact on tax revenues. If the level of aid has high year-on-year variability, any impact aid has on tax revenues may be eroded. Conversely, aid volatility may also underpin recipient countries' need for revenue mobilization. Aid is likely to influence tax revenue mobilization through multiple mechanisms, with the effects being country-

specific.[1] Lone focus on the amount of aid conflates the ways in which aid can influence taxes, and this paper disentangles these different ways through which aid shapes revenue (tax) performance.

Extant empirical literature addressing the effect of aid (usually disaggregated into grants and loans) on tax revenue has been dominated by individual country studies estimating fiscal response models (FRMs) and cross-country regressions (including aid among the determinants of the tax/GDP ratio). Country-specific studies addressing the fiscal effects of aid typically find aid to be associated with increased tax revenue (Osei, Morrissey and Lloyd, 2005 for Ghana; Mascagni and Timmis, 2017 for Ethiopia; Bwire, Lloyd and Morrissey, 2017 for Uganda). For the cross-country studies, some find that aid crowds out tax revenue (Remmer, 2004; Bräutigam and Knack, 2004) – and go as far as positing that grants (with no obligations for repayment) crowd out tax revenue and loans encourage tax effort (see *inter alia*, Gupta, Clemens, Pivovarsky and Tiongson, 2004; Benedek, Crivelli, Gupta and Muthoora, 2012) - while others find a positive (typically meagre) impact of aid on tax revenues (Clist and Morrissey, 2011; Clist, 2016; Gupta, 2007 among others). Generally, these panel estimates provide no consensus as results are sensitive to specification, empirical strategy, sample and data. We propose four reasons for dissension in the literature: persistence in fiscal data, measuring aid and tax (as distinct from non-tax revenue), cross-country heterogeneity and endogeneity; and state how we attempt to circumvent these difficulties.

First, the studies apply standard panel approaches (OLS, fixed effects, difference and system GMM) which typically ignore the time-series properties of the data, thus ignoring potential long-run (levels) relationships between aid and tax ratios. Fiscal variables are usually trending (nonstationary) in the long-run, hence in a levels specification a mixture of stationary and nonstationary variables, or a mixture of nonstationary variables of different order may lead to unreliable results (Herzer and Morrissey, 2013). Carter (2013) uses more flexible empirical methods (allowing for variable nonstationarity) and finds a marginal, positive impact of aid on taxes. Our approach, like Carter's (2013), considers the time series properties and dynamics of the data, permitting us to make credible claims about long-run (equilibrium) and short-run relationships between the aid/GDP and tax/GDP ratios. Specifically, we test for the existence of a long-run equilibrium (cointegrating) relationship between aid and taxes in the panel of 84 developing countries; and provide estimates for the long-run and short-run parameters.

Second, measuring aid and revenue in a way that best describes behavioural effects. Regarding aid, the analyst is interested in getting a measure of aid that has behavioural effects on taxes, that is aid that goes through recipient governments' budgets (or at least a measure of aid 'close' to that which goes through the budget). Only in the recent past has aid data specifically for DRM been available (and it is considerably smaller than social sector aid), with most studies in the tax performance literature using net aid (as a proportion of GDP) instead. For time-series analysis, this is an innate limitation beyond the scope of the analyst since data on aid for DRM is available from 1995 onwards: which amounts to 18 years of data in this sample, making it inadequate for meaningful time series analysis. Nonetheless, the aid/GDP ratio is likely to be problematic because: (i) not all aid is expected to influence recipients' tax/GDP ratios. Some aid finances human and physical capital development, and based on the total aid/GDP ratio it is uncertain how much of the aid is meant for DRM. Additionally, such a broad measure of aid likely includes technical assistance, and as argued in section 2: technical assistance and policy conditionality, independent of the amount of aid, play an important role in influencing DRM. (ii) more aid tends to go to countries

[1] At a broad level, aid has macroeconomic effects (through its potential influence on growth) and tax revenues are affected by macroeconomic performance, through an expanding tax base. Thus, there might be indirect effects of aid on taxes through its effects on macroeconomic performance. This possibility is not explored in this paper mainly because there is a myriad of factors that potentially influence growth, and it is uncertain whether aid is one of such factors. Even if the effects of aid on growth depend on other conditioning variables, the exact conditioning variables are unknown (Herzer and Morrissey, 2013).

experiencing growth-retarding factors independent of their ability to raise tax revenue (or lack thereof), creating endogeneity concerns.

Regarding tax revenue, most studies use total revenue: tax and non-tax revenue (which includes revenue from natural resources), but interest should be on non-resource tax revenue as that is the revenue category expected to respond to aid. Gupta *et al.,* (2004), Clist and Morrissey (2011), Benedek *et al.,* (2012), and Carter (2013) use total government revenue while Crivelli and Gupta (2017) and Combes, Ouedraogo and Tapsoba (2016) use tax revenue data; the studies obtaining data from the International Monetary Fund (IMF) databases. Morrissey, Prichard and Torrance (2014), Morrissey and Torrance (2015) use tax revenue data (excluding natural resource revenue) from the Government Revenue Dataset (GRD) compiled by the International Centre for Tax and Development (ICTD) and the United Nations University World Institute for Development Economics Research (UNU-WIDER). In this paper, we use a measure of net aid void of technical assistance (see section 3), and a measure of tax revenue (void of natural resource components) like the measure used by Morrissey and Torrance (2015).

Third, the cross-country studies ignore heterogeneity in fiscal effects, with institutional differences across countries fundamental in permeating the impact of aid on taxes. Recently, there have been country-specific studies estimating the fiscal effects of aid and the general conclusion from those studies is that aid is associated with increased domestic revenue (see *inter alia* Osei *et al.,* 2005; Mascagni and Timmis, 2017; Bwire *et al.,* 2017). In this paper, we build on the country-specific, time series analysis by estimating the effect of aid (and its components) on taxes, over time on average, in a panel of 84 developing countries, allowing for those effects to differ across countries; and disentangling the different ways through which aid influences taxes.

Fourth, potential aid endogeneity plagues existing cross-country approaches. Poor countries that attract aid typically have low tax/GDP ratios (because of weak tax bases); and aid flows (especially grants) are higher to countries facing difficulties in raising revenue. This creates a reverse causality problem, and the literature attempts to control for this endogeneity using instrumental variable and GMM techniques. However, Temple (1999) documents the difficulty in finding variables that qualify as instruments, alongside the spuriousness of estimates when the instruments are weak or invalid. This means previous results may be tenuous; hence they should be interpreted with caution.

Closely related to the issue of endogeneity is cross-section dependence. Internal and external factors that influence recipients' taxation capacities, and potentially the amount of aid they receive (for example, the recent financial crisis resulted in fiscal austerity in donor countries, impinging on their aid disbursement patterns), create interdependencies across countries. This means in standard panel data approaches that the country variable series, as well as residuals from country-specific regressions, will be correlated. Such correlations are palpable in macro panel data, and ignoring them results in inconsistent and biased estimates (Chudik and Pesaran, 2015). The conventional approach to dealing with common shocks has been to include time dummies. However, this approach implicitly assumes that the effects of the shocks are identical across countries; which may not be true since institutional differences across countries ensure that they respond differently to shocks. Hence in this paper we employ nonstationary panel methods that allow for heterogeneous cross-section correlation and test for the existence of a long-run (equilibrium) relationship between aid and taxes. We then test for exogeneity (direction of long-run causality) in taxes and aid, providing evidence on how recipients and donors react to deviations from the equilibrium.

Specifically, our findings are five-fold. First, the results provide evidence of a long-run equilibrium (cointegrating) relationship between aid and taxes which represents a behavioural relationship between aid and taxes. The average long-run effect of aid on taxes is positive, and robust to variable and residual correlation, outliers and omitted variables. Second, the composition of aid matters as grants are associated with increases in tax/GDP ratios in developing countries. This contrasts with Gupta *et al.,* (2004) and Benedek *et al.,* (2012) but is consistent with Clist and Morrissey (2011) and Mascagni and Timmis (2017).

We argue that the political costs of accountability for grants outweigh the political costs of tax, such that recipients will prefer tax increases to aid-dependence. Third, technical assistance is vital in improving revenue performance (and fiscal policy in general) in developing countries; especially through its impact on improving tax administration, assisting in implementing policy reforms and establishing revenue authorities. Fourth, for countries with *met* revenue conditionality in IMF-supported programs aid has a positive long-run relationship on tax revenues. Fifth, long-run causality runs from aid to taxes, suggesting that on average (or in general), changes in aid induce permanent changes in taxes. Aid, on the other hand, is weakly exogenous; emphasising our claims of a behavioural representation in which taxes adjust positively to changes in aid.

The rest of the paper is organized as follows: Section 2 provides a conceptual framework from which hypotheses will be tested; emphasising the ways through which aid can shape tax performance, as well as the econometric issues faced in estimating the effects of aid on taxes. Section 3 presents a brief discussion of the data used in the analysis while section 4 sets out the empirical model specification. Section 5 presents results for tests for cross-section dependence and unit roots, estimates for the impact of aid on taxes, as well as results from exploratory analysis and analysis of weak exogeneity. Section 6 concludes.

2 Conceptual framework and related literature

2.1 Conceptualizing the dynamics between aid and taxation

In least developed countries (LDCs) domestic revenue is too low to finance the provision of public goods and services required for growth and development; reason why they receive aid and that aid is more likely to be in the form of grants. Low domestic revenue does not imply that tax effort is weak, nor does it signify fiscal nonchalance on the part of recipient governments' policy-makers. Given the relatively small tax bases in these countries, which in part reflects their large informal and agricultural sectors, revenue mobilization may be as high as feasible but is still not enough to generate economic gains (Keen and Simone, 2004; Morrissey, 2015). Due to these revenue constraints, aid provides a direct alternative source of revenue. This makes the choice between tax and aid a complex one, and there are legitimate concerns as to whether aid is a complement to or a substitute for domestically raised revenue. In exploring the relationship between aid and taxes, the alternative ways through which aid can influence tax revenue mobilization must be considered.

First, most studies of tax performance (*inter alia* Gupta *et al.,* 2004; Benedek *et al.,* 2012) assume that in recipient countries there is a behavioural impact of aid on tax revenue: because aid (especially grants) provides revenue, governments are less inclined to expend political and administrative effort on tax collection. This is plausible because increasing taxes is unpopular, and recipients may see aid as a politically less costly source of revenue to cover government expenditure; reducing the urgency of tax revenue collection. However, there are also political costs associated with aid: increased dependency; costs of accountability (donors account to their parliaments while recipient governments account to their constituencies, and donors); as well as bureaucratic costs of administration. This makes the choice between aid and tax dependent on the respective costs, and how they offset each other (Morrissey, 2015; Morrissey and Torrance, 2015). These costs are evaluated according to autonomy, accountability and bureaucratic costs.

The costs of accountability refer to whom and the extent to which a government must account for its uses of revenue, and the costs are likely to be higher for aid than taxes (Morrissey, 2015). Donor agencies have to account to their governments on how their aid is used so they implement strong monitoring mechanisms to minimize fungibility. They also attach conditions; and recipients have to expend effort in trying to circumvent the conditions. The costs of autonomy are reflected in a country's (in)ability to make

independent policy choices since aid-dependent governments cede some policy influence to donors, and lose leverage in negotiating on policy conditionality (Morrissey and Torrance, 2015). In addition, there are bureaucratic costs of tax and aid. The former relates to the costs of tax administration (with fiscal reform implemented in many developing countries tax administration has improved, reducing the bureaucratic costs of tax) while the latter, which is a function of the number of donors, refers to the costs of organising, and attending meetings with different donor agencies. The bureaucratic costs of aid are still high, and this is exacerbated by donor proliferation, disbursement heterogeneity, and the changing requirements on monitoring aid. Knack and Rahman (2007) discuss the short-term and long-term costs of donor fragmentation: the former relating to unnecessary waste of resources and duplication of country analytic work (such public expenditure reviews and poverty assessment reports), resulting in high transaction costs. The longer-term costs undermine the quality of governance in already weak administrations characterising developing countries; for example, the use of expatriates instead building domestic capacity through 'learning by doing', and funding investment projects with high recurrent costs in future years.

This line of argument suggests that if the political costs of taxation are higher than those of aid (which is an implicit assumption from the Remmer, 2004; Gupta *et al.,* 2004 and Benedek *et al.,* 2012 findings), recipients will choose to expend less effort on tax collection; and this will be reflected empirically by the negative relationship between aid and taxes. Conversely, if the political costs of aid are higher, then recipients expend more effort on tax collection while systematically reducing the aid they receive. Empirically, this will be reflected by a positive relationship between aid and taxes.

Second, Morrissey and Torrance (2015) state that transfer of knowledge and capacity building from donors through technical assistance, as distinct from the amount of aid *per se*, is what potentially influences revenue mobilization through strengthening of weak tax institutions and improving the formulation of tax policy. Technical assistance also has the potential to relax capacity constraints in implementing institutional policy reforms; thereby improving revenue performance in developing countries. Third, donor-instigated policies and institutional reforms, such as trade liberalization, currency devaluation, creation of revenue administration and enforcement agencies, might also be associated with changes in tax revenues (Clist and Morrissey, 2011), with the country-specific effects potentially moving in opposite directions. The net tax effects of such policy reforms are thus uncertain (Carter, 2013); and it is difficult to distinguish between the direct causal effects of aid on taxes, and effects that can be associated with changes in policy reforms. This is exacerbated by donor and aid proliferation; with many recipients having multiple donor-instigated initiatives implemented over the years (Carter, 2013). Fiscal reforms supported by donors may improve tax administration and collection efficiency, but this may not necessarily translate to an observable increase in tax revenue (Morrissey *et al.,* 2014).

Fourth, donor conditionality associated with aid would also have effects on tax revenue through its effect on tax rates, tax collection and the tax base (Morrissey *et al.,* 2014). Conditionality takes different forms, including prior actions (measures a country agrees to take before financing is approved or a review is completed), quantitative performance criteria (specific and quantifiable conditions that have to be met to complete a review, relating to macroeconomic variables under the control of the recipient), indicative targets (established to supplement quantitative performance targets) and structural benchmarks (typically non-quantifiable reform measures intended to assess program implementation during a review). Crivelli and Gupta (2016) find that revenue conditionality in IMF-supported programs has a positive impact on tax revenue performance in 126 developing countries from 1993–2013, while Brun, Chambas and Laporte (2010) find evidence of a positive impact of donor-supported conditionality on total revenues in Sub-Saharan Africa from 1984-2007. Crivelli and Gupta (2017) state that other donors tend to rely on the IMF to implement macroeconomic conditionality, such that focusing on revenue conditionality from the IMF is enough to capture broader donor conditionality accompanying aid.

Fifth, the impact of aid on tax revenues may be influenced by donor policies; particularly the stability of donor-recipient relationships and how they relate to the stability of aid flows to developing countries (Lensink and Morrissey, 2000). There is a degree of continuity in donor-recipient relations such that recipients expect to receive aid every year. These recipient governments also have some form of expectations of the exact amount of aid to be received, as aid commitments are known some time in advance (Lensink and Morrissey, 2000). Additionally, knowing past values of aid flows; recipients expect some variability in aid so they plan fiscal policy accordingly. Thus, if disbursement (donor) difficulties create relatively high year-on-year variation in the level of aid, there may be no discernible impact of aid on tax ratios as aid is too unpredictable to be useful for planning (implementing reforms that will help to improve fiscal performance); with a net effect of zero. Plausibly, increased aid instability may result in fiscal vulnerability in developing countries, resulting in reduced tax/GDP ratios. Aid receipts may also vary due to macroeconomic uncertainty; causing donors to deviate from recipients' expectations, creating some unanticipated instability in aid which may also determine the way aid impacts on tax revenues. It is conceivable that more aid instability will mean countries need to strengthen DRM and shift from aid dependence to tax reliance. Ultimately, the impact of aid volatility on tax performance can be deciphered empirically.

2.2 Econometrics

In this sub-section, we motivate the empirical issues faced with estimating cross-country effects of aid on taxes: the heterogeneous nature of the aid-tax relationship, time series properties and dynamics characterising the data, as well as endogeneity and ensuing cross-section dependence in the aid-tax relationship. We begin by discussing time-series properties of the data, and then proceed to motivate cross-country heterogeneity, endogeneity and cross-section properties of the data.

Aid/GDP and tax/GDP ratios are typically approximated by stochastic (through the presence of a unit root), rather than deterministic (through the presence of higher order time trends) processes (Herzer, 2017). That implies for most developing countries both aid/GDP and tax/GDP ratios are non-stationary in the long-run, albeit with positive and/or negative trends. Thus, a linear combination of these non-stationary variables is stationary if aid/GDP and tax/GDP ratios are cointegrated (Engle and Granger, 1987; Granger and Newbold, 1974); that is if there is a long-run equilibrium relationship between the aid/GDP and tax/GDP ratios and permanent changes in the aid/GDP ratio are associated with permanent changes in the tax/GDP ratio. If both variables are not cointegrated then any linear combination between them is spurious (Granger and Newbold, 1974); a situation where even if aid/GDP and tax/GDP ratios are unrelated, the regression results indicate a highly significant relationship since standard tests for significance and goodness of fit are now invalid. A salient characteristic of heterogeneity in fiscal effects is the presence of heterogeneous cointegration; that is the long-run relationship between aid/GDP and tax/GDP ratios differs for all countries in the sample.

There is pervasive heterogeneity in government fiscal behaviour across developing countries; with domestic political and economic, internal and external, factors interacting with foreign aid (and its components) in different ways across recipient countries. This creates heterogeneous tax/GDP ratios across countries over time. Furthermore, the standard revenue (tax) performance equation is a contemporaneous relationship whereby the current tax/GDP ratio is determined by current values of the economic structure variables (Clist and Morrissey, 2011; Carter, 2013) which represent the determinants of taxable capacity. These country level determinants of tax/GDP ratios are not captured by available data (Morrissey, 2015), resulting in the use of (often poor) proxy variables for the tax base; such as *per capita* income, sectoral output shares of agriculture, manufacturing and trade. In addition, these data do not account for policy changes in tax rates and tax administration.

Nonetheless, changes in the proxy variables will be associated with contemporaneous changes in tax/GDP ratios but the relationship between the aid/GDP and tax/GDP ratios (the relationship of

primary theoretical interest in this paper), is most likely dynamic since taxation policy and tax systems are statutory; making tax/GDP ratios highly persistent over time (at least in the short-run). Changing tax structures, tax rates and improving the efficiency of tax collection are all time-consuming processes, delaying the potential impact of aid. Furthermore, faced with the uncertainties of changes (increases/decreases) in the level of aid, recipient governments may delay in altering fiscal policy (O'Connell, Adam and Buffie, 2008); underscoring the importance of dynamics in the relationship between aid and taxes.

Introducing dynamics in the relationship between aid and taxes allows for the possibility of feedback between both variables, with revenue performance in recipient countries potentially influencing donor aid allocation; creating a reverse causality problem. It is also conceivable that there is a bi-directional (simultaneous) relationship; with recipients' structural characteristics determining both high (low) aid and low (high) revenue. Clist and Morrissey (2011) and Morrissey and Torrance (2015) argue that lagging aid by one or two years as is done in previous studies (see *inter alia* Gupta *et al.,* 2004; Benedek *et al.,* 2012) is insufficient to curb the simultaneity. Due to the persistence of tax/GDP ratios, uncertainties of the timeline for which aid is likely to influence revenue performance, and because the innate structural characteristics determining both low tax and high aid change slowly, longer lags of aid are needed to deal with simultaneity. Morrissey and Torrance (2015) attempt to deal with endogeneity by using longer lags of aid.

In a (panel) time series context, however, endogeneity is dealt with differently. If aid and taxes are both nonstationary and co-integrated, then tests for weak exogeneity (i.e. the direction of long-run causality) are applicable. If donors, in their aid allocation decisions respond to changes in revenue performance in receiving countries, this implies aid is endogenous for the long-run equilibrium; suggesting a behavioural impact of taxes on aid for the donors. If donors do not respond to such changes in their allocation decisions but aid/GDP influences tax/GDP ratios, aid is weakly exogenous or *long-run forcing* (Lloyd, McGillivray, Morrissey and Opoku-Afari, 2009).

Tax ratios, hence revenue performance may be determined by unobserved country-specific factors (Morrissey and Torrance, 2015), such as indigenous institutions, colonial heritage and resource endowments. The unobserved factors may be influenced by shocks that affect all countries to varying degrees (for example the recent financial crisis or the 1970s oil crises) or by multiple economic, social and cultural ties between countries; representing mere spill-over effects. In addition, the individual evolution paths of the unobservables are unrestricted to simple linear trends, allowing for non-linearity and nonstationary in evolution (Eberhardt and Teal, 2013). Interest is in the cross-country average effect of aid/GDP ratios on tax/GDP ratios, making the use of annual time-series data appropriate (Clist and Morrissey, 2011). However, use of annual data raises concerns about the distorting influence of business cycles on empirical inference (Eberhardt and Teal, 2013; Temple, 1999), such that analysis is usually carried out with time-averaged data (Morrissey and Torrance, 2015; Morrissey *et al.,* 2014). In this study, we argue that adopting a common factor approach deals with any business cycle effects, whether they represent spill-over effects (idiosyncratic to a small number of countries) or global shocks with more profound, albeit heterogeneous impacts.

In summary, the effect of foreign aid on taxation depends on several factors, the most important of which are the dynamic political and economic factors. These factors, themselves influenced by policy changes, are not captured by available data hence not adequately incorporated into econometric specifications. In addition to the data concerns, donor-supported reforms and conditionality, and technical assistance, independent of the level of aid, also influence revenue performance. Furthermore, institutions are country-specific, and tax systems and policy display strong persistence over time; such that the dynamic relationship between aid and taxation is specific to each country. These issues will be addressed in the empirical analysis.

3 Data

For the econometric analysis, we collect data on 84 developing countries covering the period 1980 to 2013. Data on net aid disbursements, gross aid disbursements, gross aid loans, gross aid grants and technical assistance are sourced from the OECD's Development Assistance Committee (2016) database. One of the objectives of this study is to estimate, independently, the impact of technical assistance on tax/GDP ratios in developing countries. Thus, we need to measure aid in a way that influences taxes (typically a measure of aid 'close' that which goes through recipients' budgets). We deduct technical assistance from grants to obtain a new measure of grants which we then add to net loans to get net ODA figures for the econometric analysis; and scale it with real GDP data (constant US$ 2010) sourced from the IMF's *World Economic Outlook*. We also estimate variants of the main model with grants, loans and technical assistance (all as percentages of GDP) as regressors of primary interest.[2]

For data on domestic revenue mobilization we rely on the Government Revenue Dataset (GRD 2016) from the International Centre for Tax and Development (ICTD) and the United Nations University World Institute for Development Economics research (UNU-WIDER). This includes non-resource tax revenue, total tax revenue and total government revenue; all excluding grants and social contributions so we get measures of domestic revenue suitable for econometric analysis (Prichard, Cobham and Goodall, 2014). The data are then scaled by GDP series (sourced from the *World Economic Outlook*) in local currency units. Non-resource tax revenue excludes royalties and natural resource taxes (Prichard *et al.,* 2014). Total tax revenue comprises all direct and indirect tax revenues while total government revenue is a composite of all tax and non-tax revenues (for instance, central bank receipts). The UNU-WIDER/ICTD GRD (2016) dataset has two major advantages over other tax datasets.

First, it combines fiscal revenue data from major international databases (for example the *Government Finance Statistics* database which suffer from missing values), as well as IMF Article IV reports and national budgets. This significantly improves data coverage, particularly in the more recent past (from the 1990s onwards). Second, it attempts to distinguish between resource and non-resource components of tax revenue, allowing for consistency in the treatment of natural resource revenue in econometric analyses, while also permitting the construction of a tax variable exclusive of natural resources. This is very important as fiscal theory posits that aid should affect only non-resource taxation (Morrissey *et al.,* 2014).

[2] Emergency aid and development food aid are off-budget aid but are excluded from the analysis. The most basic reason is such aid are designed to deal with economic and social crises, and by implication are volatile (Fielding and Mavrotas, 2005).

Table 1A: Average aid/GDP and non-resource tax/GDP ratios over the sample period

	Aid/GDP	Tax/GDP		Aid/GDP	Tax/GDP
Algeria	0.26	11.73	Madagascar	7.55	9.69
Angola	1.90	6.67	Malawi	10.40	14.56
Argentina	0.04	15.07	Maldives	4.40	10.74
Bangladesh	2.11	5.91	Mali	9.23	10.89
Belize	2.75	20.05	Mauritania	11.40	12.61
Benin	0.32	12.87	Mauritius	1.04	17.57
Bhutan	10.34	8.23	Mexico	0.03	9.26
Botswana	2.02	15.02	Morocco	1.43	20.34
Burkina Faso	9.31	10.31	Mozambique	16.41	10.54
Burundi	16.44	12.23	Nepal	5.29	8.49
Cameroon	2.95	10.28	Nicaragua	8.90	14.24
Cape Verde	15.45	15.36	Niger	10.16	9.13
CAR	8.57	9.24	Pakistan	1.20	9.85
Chad	6.70	5.03	Panama	0.33	11.24
Chile	0.08	16.11	Papua New Guinea	3.61	18.00
China	0.14	15.03	Paraguay	0.70	10.16
Colombia	0.21	9.49	Peru	0.54	13.37
Comoros	11.59	11.23	Philippines	0.67	13.03
Congo Rep.	4.17	10.25	Rwanda	14.02	9.96
Costa Rica	0.87	1.11	Sao Tome & Principe	27.03	10.13
Cote D'Ivoire	3.50	16.13	Senegal	7.15	15.86
Dominica	5.53	20.27	Seychelles	3.35	30.46
Dominican Republic	0.44	10.30	Sierra Leone	10.84	6.99
DRC	6.17	5.69	Solomon Islands	18.34	17.19
Ecuador	0.50	8.46	Sri Lanka	2.89	15.35
Egypt	1.81	12.18	St. Vincent	3.20	20.82
El Salvador	2.85	11.11	Sudan	4.79	6.81
Eq. Guinea	8.76	10.86	Swaziland	1.74	23.62
Ethiopia	7.42	9.45	Tanzania	9.53	8.71
Gabon	0.83	10.89	Thailand	0.25	15.21
Gambia	10.38	12.62	Togo	6.54	14.71
Ghana	3.90	10.64	Tonga	10.46	15.61
Guatemala	1.06	9.51	Turkey	0.17	13.61
Guinea	5.94	7.88	Uganda	7.73	7.29
Guinea-Bissau	16.18	5.05	Uruguay	0.13	16.17
Honduras	4.05	13.06	Vanuatu	11.84	16.46
India	0.29	9.51	Venezuela	0.03	8.69
Indonesia	0.45	8.45	Zambia	9.95	15.72
Iran	0.04	5.57			
Jamaica	1.49	23.33			
Jordan	5.95	17.32			
Kenya	3.61	13.98			
Kiribati	21.93	16.36			
Laos	8.10	7.30			
Lesotho	9.88	42.07			

Notes: Aid/GDP = Aid to GDP ratio, Tax/GDP =Non-resource tax to GDP ratio. CAR – Central African Republic, DRC – Democratic Republic of Congo, Congo Rep – Republic of Congo, St. Vincent – St. Vincent and the Grenadines.

Source: Author's calculations based on OECD DAC (2016), UNU-WIDER/ICTD GRD (2016).

Table 1A lists the countries along with the average values of the aid/GDP and non-resource tax/GDP ratios over the period 1980 to 2013. What is immediately apparent is the cross-country heterogeneity in the average values of the series: (i) Sao Tome and Principe and Kiribati are the most aid-dependent economies with aid amounting to over 21 percent of GDP; and their grants/GDP ratios are also very high (see appendix table A5). Some other least developed countries are still very aid-dependent with an average ratio of aid to GDP more than 15% (Burundi, Cape Verde, Guinea-Bissau, Mozambique, and Solomon Islands). (ii) Even in some least developed countries that are supposedly more aid-dependent, the aid/GDP ratio is fairly similar to the tax/GDP ratio; underscoring the burgeoning importance of

domestic revenue mobilization in developing countries. For example, for the most aid-dependent countries Cape Verde has an average aid/GDP ratio of 15.45% with a tax/GDP ratio of 15.36% and 18.34% versus 17.19% in Solomon Islands. For other least developed countries, Comoros has an average aid/GDP of 11.59% with an average tax/GDP ratio of 11.23%, Mali 9.23% against 10.89%, Niger 10.16% against 9.13%, and Tanzania 9.53% against 8.71%. (iii) Middle-income countries with the highest tax/GDP ratios tend to have the lowest aid/GDP ratios. Belize, Fiji, Argentina, Botswana, Jamaica, and Mauritius, for example, are among the countries with the highest tax/GDP and lowest aid/GDP ratios in our sample.

Table 1B: Descriptive statistics for groups of countries

	Tax/GDP	Aid/GDP	Grants/GDP	Loans/GDP	TA/GDP
All countries (84)	12.92	5.58	3.51	3.11	2.07
LDCs (38)	11.30	9.63	6.22	3.54	3.50
LICs (46)	14.30	2.27	1.29	1.21	0.89
SSA (40)	12.51	8.08	5.48	3.36	2.53
LAC (19)	13.37	1.61	0.97	0.98	0.57
MENA (6)	13.48	1.61	1.04	0.94	0.43
AsiaPAC (18)	12.87	5.69	2.73	1.62	3.24
RR (26)	11.30	4.10	2.74	1.77	1.26
NRR (58)	13.62	6.24	3.85	2.47	2.43

Notes: LDCs = Least Developed Countries; LICs = Other Low-income Countries; SSA = Sub-Saharan Africa; LAC = Latin America and the Caribbean's; MENA = Middle East and North Africa; AsiaPAC = Asia and the Pacific. RR = Resource Rich Countries; NRR = Non-Resource Rich Countries. Tax/GDP = non-resource tax/GDP ratio; TA/GDP = Technical assistance to GDP ratio.

Sources: Author's calculation based on OECD DAC (2016), UNU-WIDER/ICTD GRD (2016).

On average, least developed countries have a higher aid/GDP ratio and lower non-resource tax/GDP ratio than other low-income countries (see table 1B). The average grants/GDP is also greater than the average loans/GDP for these LDCs, reflecting their relatively lower income levels. These basic statistics point to the simultaneity problem mentioned in section 2: LDCs with weak tax bases receiving more aid in the form of grants. Across regions, SSA has the highest aid/GDP, grants/GDP and loans/GDP ratios and the lowest average non-resource tax/GDP ratio. 31 of the 38 LDCs are Sub-Saharan African countries which face difficulties in raising domestic revenue; hence, receive more aid (especially in grants). Resource rich countries have lower non-resource tax/GDP ratios than their non-resource rich counterparts.

4 Emperical model specifications

4.1 Linear dynamic model

To estimate the relationship between the aid/GDP and tax/GDP ratios in country i at time t we employ a multifactor error framework of the form:

$$tax_{it} = \beta_i' aid_{it} + u_{it} \qquad u_{it} = \alpha_i + \lambda_i' f_t + \varepsilon_{it} \tag{1}$$

where tax_{it} is the log of the tax/GDP ratio over time periods t=1, 2,…, T and countries i=1, 2,…, N. aid_{it} is the log of the percentage of net Official Development Assistance (excluding technical assistance) to GDP. The vector of parameter coefficients (β_i) differs across countries, but is constant over time. Equation (1) also includes country-specific intercepts (α_i) and a vector of unobserved common factors f_t with country-specific factor loadings λ_i to account for the levels and evolution of unobservables, respectively. We allow for the possibility that the growth of unobservables not only differs across countries, but within countries over time (Eberhardt and Vollrath, 2016); with the main concern now

being how to separate the country-time specific shock, λ_{it}, from the random error term, ε_{it}. However, we can model such country-specific unobservable evolution by adopting a multi-error factor structure for the error term, u_{it}. Let

$$u_{it} = \alpha_i + \lambda_i' f_t + \varepsilon_{it} = \alpha_i + \lambda_{S,i}^{S} f_t^{S} + \lambda_{W,i}^{W} f_t^{W} + \varepsilon_{it} \quad (2)$$

where the common factors, which are orthogonal to each other, can be a combination of a limited number of 'strong' factors (f^S) (following Stock and Watson, 2002) and an infinite number of 'weak' factors (f^W) (Chudik, Pesaran and Tosetti, 2011). Strong shocks like the global recession of the 1980s and the recent financial crisis are assumed to affect all countries, albeit to varying degrees. Weak shocks, (for example, the devaluation of the CFA franc in 1994 and the Arab Spring in 2011) on the other hand, affect only a sub-sample of countries so they represent localized (spill-over) effects. In addition, the unobservable factors not only drive tax/GDP ratios, but also aid/GDP ratios: creating an endogeneity problem (Kapetanios *et al.,* 2011) whereby the parameter β_i^{aid} is not identified unless (i) we can account for the unobservable factors in the error term u, or (ii) provide a *valid* and *informative* set of instruments for potentially endogenous aid. Nonetheless, Bazzi and Clemens (2013) state that satisfactory instruments are unavailable. Furthermore, standard instrumental variables techniques are inappropriate in this set up due to the heterogeneous equilibrium relationships across countries (Eberhardt and Presbitero, 2015) and the omnipresence of unobserved common factors (Eberhardt and Presbitero, 2015; Temple and Van de Sijpe, 2017). The unobserved common factors can also be nonstationary, with implications for estimation and inference since both observable and unobservable processes in the model are now integrated (Kao, 1999; Eberhardt and Presbitero, 2015).

Given the importance of dynamics and time series properties of aid/GDP and tax/GDP ratios, we employ an unconditional error correction model (ECM)[3] of the form:

$$\Delta tax_{it} = \alpha_i + \rho_i\left(tax_{it-1} - \beta_i^{aid} aid_{it-1} - \lambda_i' f_{t-1}\right) + \gamma_i^{aid}\Delta aid_{it} + \gamma_i^{F}\Delta f_t + \varepsilon_{it} \quad (3)$$

where the expression in brackets represents the potential cointegrating relationship we seek to identify, β_i^{aid} represents the long-run equilibrium (cointegrating) relationship between the tax/GDP and aid/GDP ratios, the γ_i^{j} represent the short-run adjustment dynamics and ρ_i indicates the speed of convergence of the economy to its long-run equilibrium. Unobserved common factors f are included in the long-run relation, which implies we will investigate an equilibrium relationship between taxes, aid and the unobservables. We can test for cointegration in the ECM based on the statistical significance of the error correction term in the ECM, with a negative and significant error correction coefficient representing cointegration; indicating that the economy returns to its long-run equilibrium following a deviation.

Finding cointegration between the tax/GDP and aid/GDP ratios is important as it would imply no potentially important nonstationary variables have been omitted from estimation: any omitted nonstationary variable that is part of the cointegrating relationship will now be part of the error, producing nonstationary residuals and failure to detect cointegration (Herzer, 2017; Herzer and Morrissey, 2013). Lütkepohl (2007) states that if there is cointegration between a set of variables, then this property extends into the variable space. There are many determinants of tax revenue performance, most of which are nonstationary (for example, export- and import-to-GDP ratios), which if included in our model may result in further cointegrating relations. The original cointegrating relation, however, is unaffected by these recently included nonstationary variables.

[3] See Tagem (2017) and Eberhardt and Presbitero (2015) for advantages of a heterogeneous ECM specification over static and/or more restrictive dynamic specifications.

To estimate the dynamic ECM in equation (3) given the common factor framework we focus on novel panel time series estimators that allow for heterogeneity in the aid-tax relationship and cross-section dependence. Following Pesaran (2006), the Common Correlated Effects Mean Group (CCEMG) estimator uses (weighted) cross-section averages of the dependent ($\overline{tax}_t$) and independent variables ($\overline{aid}_t$) constructed to filter out the unobserved common factors f and omitted elements of the cointegrating relationship. Kapetanios *et al.,* (2011) and Coakley, Fuertes and Smith (2006) show that the estimator is consistent in the presence of cointegration and non-cointegration of the model variables, structural breaks, nonstationary common factors, regressor-specific common factors, factor loading dependence and the presence of multiple common factors. Augmenting equation (3) with cross-section averages of the dependent and independent variables we get:

$$\Delta tax_{it} = \pi_{0i} + \pi_i^{EC} tax_{it-1} + \pi_i^{aid} aid_{it-1} + \Phi_i^{aid} \Delta aid_{it} + \pi_{1i}^{CA} \overline{\Delta tax}_t + \pi_{2i}^{CA} \overline{tax}_{t-1} + \pi_{3i}^{CA} \overline{aid}_{t-1} + \pi_{4i}^{CA} \overline{\Delta aid}_t + \varepsilon_{it} \quad (4)$$

Chudik and Pesaran (2015) extend the standard Pesaran (2006) approach to accommodate dynamics (feedback) from weakly exogenous regressors (a result of the inclusion of a lagged dependent variable); and find that the standard CCEMG is subject to small sample bias, especially in samples of moderate time series (30 to 50 years of annual time-series data). Chudik and Pesaran (2015) provide an empirical strategy to deal with the bias: in addition to the cross-section averages from the standard CCEMG, they suggest including lags of cross-section averages in the ECM, in our setup

$$\Delta tax_{it} = \pi_{0i} + \pi_i^{EC} tax_{it-1} + \pi_i^{aid} aid_{it-1} + \Phi_i^{aid} \Delta aid_{it} + \pi_{1i}^{CA} \overline{\Delta tax}_t + \pi_{2i}^{CA} \overline{tax}_{t-1} + \pi_{3i}^{CA} \overline{aid}_{t-1} + \pi_{4i}^{CA} \overline{\Delta aid}_t + \sum_{l=1}^{p} \pi_{5i}^{CA} \overline{\Delta tax}_{t-p} + \sum_{l=1}^{p} \pi_{6i}^{CA} \overline{\Delta aid}_{t-p} + \varepsilon_{it} \quad (5)$$

and/or the inclusion of cross-section averages of one or more further covariates (other than aid) which may help identify the multiple unobserved factors. In our setup,

$$\sum_{l=0}^{p} \pi_{7i}^{CA} \overline{\Delta \Upsilon}_{t-p}$$

where the π_s and Φ_s represent the long-run and short-run coefficients respectively, the $\pi^{CA}{}_s$ represent the coefficients on the cross-section averages of the dependent and independent variables (all coefficients yielding the standard CCEMG estimator), and Υ represents further covariates included in the model. The $\sum_{l=1}^{p} \pi^{CA}{}_s$ represent the coefficients on the additional lags of cross-section averages which Chudik and Pesaran (2015) suggest be added to the standard CCEMG estimator (yielding the dynamic CCEMG estimator). As a rule of thumb, the lags of the cross-section averages to be added to the standard model are chosen by $p = T^{\frac{1}{3}}$ (Chudik and Pesaran, 2015). The country-series for additional covariates *do not* enter the model as regressors; just their cross-section averages and lags of cross-section averages enter the model. The objective here is to help identify the unobserved common factors f_t so including variables that may be directly linked to the tax/GDP ratio is reasonable. Therefore, we include any of the robust determinants of tax revenue performance fit for purpose (*per capita* income, the share of agricultural value added in GDP, and/or exports – all in logs), following Gupta (2007).

Chudik and Pesaran (2015) show that once the CCEMG estimator has been augmented with the sufficient number of lags and/or lags of other covariates, the estimator is unbiased in the presence of dynamics (the lagged dependent variable), and in the presence of weakly exogenous regressors. We estimate equation (5) by relaxing the common factor restriction between the parameters ρ_i and β_i implicit in equation (3) and reparametrize the model following Eberhardt and Presbitero (2015). From the levels terms (π_i^{aid}) we obtain the long-run coefficient on aid in the form:

$$\beta_i^{aid} = -\frac{\pi_i^{aid}}{\pi_i^{EC}} \quad (5^*)$$

whereas the regression coefficients on the terms in first differences capture the short-run (transitory) effects, and can be read off directly from estimation. Inference on π_i^{EC}, the speed of convergence to equilibrium, provides insights into the presence of a long-run (cointegrating) relationship between aid and taxes. If $\pi_i^{EC} = 0$ then there is no cointegraion, and the model reduces to one with variables in first differences. If $\pi_i^{EC} \neq 0$ then there is 'error correction' in the model. That is, following a shock the economy returns to its long-run equilibrium path, and therefore there exists a cointegrating relationship between aid and taxes.

4.2 Endogeneity and causality

So far, we have discussed one type of endogeneity; whereby the unobserved common factors drive both the dependent variable and the independent variables. In studying the relationship between aid and taxes (and other macroeconomic variables in general), one must consider the fact that aid is allocated in a non-random manner (Temple and Van de Sijpe, 2017; Carter, 2013). Structural characteristics may determine both low (high) revenue and high (low) aid; with poor countries that have weak tax bases and low tax ratios attracting more aid and vice versa. Thus, interest is in investigating if donors respond to recipients' fiscal imbalances when disbursing aid, or if disbursement is independent of the fiscal situation in recipient countries. To test for causality, we follow the procedure in Canning and Pedroni (2008) and Eberhardt and Teal (2013).

Provided there exists a cointegrating relationship between the aid/GDP and tax/GDP ratios the Granger Representation Theorem (Engle and Granger, 1987) states that at least one variable must adjust to maintain an equilibrium relation; and the variables can be represented in the form of a dynamic ECM. For a pair of cointegrated variables, we can then test for weak exogeneity in the following models:

$$\Delta tax_{it} = \rho_{1i} + \theta_{1i}\hat{e}_{it-1} + \sum_{j=1}^{K} \lambda_{11ij}\Delta \text{tax}_{it-j} + \sum_{j=1}^{K} \lambda_{12ij}\Delta aid_{it-j} + \epsilon_{it}^{tax} \quad (6)$$

$$\Delta aid_{it} = \rho_{2i} + \theta_{2i}\hat{e}_{it-1} + \sum_{j=1}^{K} \lambda_{21ij}\Delta aid_{it-j} + \sum_{j=1}^{K} \lambda_{22ij}\Delta tax_{it-j} + \epsilon_{it}^{aid} \quad (7)$$

where ρ_i are constant terms and $\hat{e}_{it-1}$ is the disequilibrium term $\hat{e} = y - \hat{\beta}_i x - \hat{d}$ constructed using the cointegrating relationship between the variables (d represents deterministic terms like a constant and a country-specific trend). Each variable may react to its lagged differences, as well as lagged differences of other variables in the cointegrating relationship. The Granger representation theorem implies that at least one of the adjustment coefficients θ_{1i}, θ_{2i} must be non-zero if a cointegrating (long-run) relationship between the variables is to hold (Canning and Pedroni, 2008 p. 512). If $\theta_{1i} \neq 0$ then aid_{it} has a long-run causal impact on tax_{it} and if $\theta_{2i} \neq 0$ then tax_{it} has a long-run causal impact on aid_{it}. If both θ_{1i} and θ_{2i} are non-zero then aid_{it} and tax_{it} determine each other jointly.

One of the advantages of using the disequilibrium term from a cointegrating relationship is that all the variables in equations (6) and (7) are stationary. This means once ECMs are estimated for each country, estimates for θ_i can be investigated using standard t-ratios (Canning and Pedroni, 2008; Eberhatrdt and Teal, 2013). Following Canning and Pedroni (2008) we use two separate statistics to test for weak exogeneity. The first is the group-mean statistic (GM hereafter) which averages the θ_i from individual country estimations of equations (6) and (7) and the GM test for the null of 'no long-run causal impact' is computed from the averaged t-ratio from country regressions ($\bar{t}_{\theta_2} = N^{-1}\sum_{i=1}^{N} t_{\theta_2}$). The GM statistic follows a standard normal distribution under the null hypothesis of 'no causal impact'. The second statistic is a Fisher-type (*Lambda*-Pearson) statistic which is constructed from the p-values of the t-tests

from the country regressions to get the overall marginal significance associated with those p-values. The Fisher statistic follows a x^2 distribution with $2N$ degrees of freedom under the null hypothesis of 'no causal impact'.

The null and alternative hypotheses for both tests are the same when the θ_i coefficients are the same for all members of the panel. This translates into a null that $\theta_i = 0$ for all members in the panel against an alternative $\theta_i \neq 0$ for some non-negligible members of the panel (Canning and Pedroni, 2008). The interpretation of the tests, however, differs when θ_i differs across countries. The GM test is a two-tailed test so can take on positive or negative values under the null and alternative hypothesis depending on whether $\hat{\theta}_i$ is positive or negative whereas the Fisher statistic is a one-tailed test that only takes positive values in both the null and alternative hypotheses. If these two tests fail to agree on the direction of causality between variables, this can be interpreted as θ_i being on average zero (allowing for large negative and positive values to cancel each other), but not pervasively zero in the panel (Canning and Pedroni, 2008; Eberhardt and Presbitero, 2015). If that is the case, it provides evidence of the heterogeneity of θ_i across countries.

5 Empirical results

5.1 Preliminary analysis

We investigate the cross-section correlation properties in the data using the CD test following Pesaran (2004), and report the cross-country correlation coefficients and the CD test statistic (Appendix tables A1 and A3). The results point to pervasive cross-section dependence across different variable specifications (levels versus first differences). The correlation coefficients and CD statistics are considerably lower for variables in first differences. Cross-section dependence results in over-rejection of the null hypothesis of nonstationarity in standard panel unit roots tests (Pesaran, 2007). Thus, we employ a panel unit root test, the 'CIPS' test, which allows for cross-section correlation. Appendix tables A2 and A4 provide the results from conducting the 'CIPS' test. We report the $Ztbar$ statistic (and its corresponding p-value) for H_0 = nonstationarity in all countries' variable series versus H_1 = stationarity in some countries' variable series. For both variables in levels, nonstationarity cannot be rejected once the equation is augmented with lags and/or a linear trend. Nonstationarity is rejected for both variables in first differences.

5.2 Heterogeneous baseline estimates

Having confirmed the prevalence of cross-section dependence, and established that all the variables are nonstationary in levels we proceed to estimate the heterogeneous ECM using a dynamic CCEMG estimator; results from which are reported in Table 2. We report results for the standard CCEMG (Pesaran, 2006), as well as variants augmented with one and two lags of cross-section averages respectively (Chudik and Pesaran, 2015). Long-run averages and short-run coefficients of the variables are reported. The coefficient on the lagged dependent variable is reported as well.

The long-run average coefficient is obtained by averaging ECM coefficients, then computing the long-run coefficient with standard errors computed through the Delta method. We employ the robust regression (see Hamilton, 1992) – which weighs down outliers in computing the averages – in all estimations. Relevant diagnostics (RMSE, CD test statistic, the CIPS test statistic) are reported at the bottom of the table. Given the small sample bias the standard CCEMG faces, in addition to the *favourable* results and diagnostics from the variant with two additional lags of cross-section averages, we only discuss results based on the CCEMG augmented with two lags of cross-section averages.

Both aid/GDP and tax/GDP ratios are I(1) so we can test for cointegration by investigating the statistical significance of the lagged dependent variable as shown in Table 2. Across all specifications, the coefficient on the lagged dependent variable is negative, statistically significant and different from zero, indicating that the system reverts to its equilibrium path following a shock. The results indicate that on average there is a long-run equilibrium relationship between the tax/GDP and aid/GDP ratios, with increases in the tax/GDP ratio sustained by movements in the aid/GDP ratio. Additionally, as residual testing for stationarity also provides an *ad hoc* test for cointegration, we confirmed cointegration across the three specifications.[4]

Table 2: CCEMG Estimates

	CCEMG	**One-Lag CCEMG**	**Two-Lag CCEMG**
Long-Run			
Aid/GDP	0.080***	0.086***	0.077***
	[0.027]	[0.028]	[0.027]
Short-Run			
Aid/GDP	0.011	0.009	0.014
	[0.010]	[0.011]	[0.012]
EC Coefficient			
y_{it-1}	-0.444***	-0.472***	-0.495***
	[0.027]	[0.028]	[0.031]
t-statistic	-16.57	-16.61	-16.09
Diagnostics			
RMSE	0.107	0.098	0.092
Stationarity ᵀ	I(0)	I(0)	I(0)
CD test	-0.79	-1.02	-1.45
(p-value)	(0.430)	(0.308)	(0.148)
Observations (N)	2473 (84)	2423 (84)	2371 (84)

Notes: The results are based on an error correction model for all 84 countries in the sample with the first difference of log (tax/GDP) as dependent variable. The aid/GDP ratio used is net disbursements (excluding technical assistance) as a share of recipient's GDP. 'CCEMG' represents the Pesaran (2006) common correlated effects mean group (CCEMG) estimator while 'one-lag' and 'two-lag CCEMG' represent the standard CCEMG augmented with one and two lags of the cross-section averages respectively. The long-run and short-run averages are reported, with standard errors reported below the averages. RMSE is the root mean square error, ᵀ Pesaran (2007) test results for ADF tests on the residuals: I(0) – stationary, I(1) – nonstationary. CD test is the Pesaran (2004) test distributed $N(0,1)$ under the null of cross-section independence (p-value in parantheses below). *, ** and *** indicate significance at 10%, 5% and 1% respectively.

Source: Author's calculations.

The long-run average coefficient on the aid/GDP ratio is positive and statistically significant across models. This average effect is robust to outliers, omitted variables and structural breaks. We treat this long-run as a behavioural relationship between aid and taxes, based on political costs associated with aid and taxes, for two reasons. First, our measure of aid is close to that which goes through the budget, such that it will have a direct impact on taxation. Second, the ECM distinguishes between short-run and long-run effects; such that for the long-run effect it is not essential to specify the variable lags (as *per* Clist and Morrissey, 2011; Morrissey, 2015 and Morrissey and Torrance, 2015) through which aid will impact taxes (Herzer and Grimm, 2012). On average, the evidence suggests that the political costs of aid are likely higher than those of taxes.

The costs of accountability of aid are likely higher than those of tax. Some donor agencies may operate in domestic environments where there are opponents to aid (usually political parties or vocal politicians), especially in cases where some aid projects financed by said donor agencies failed; thereby increasing the accountability costs of aid. The accountability costs of tax are much lower, especially developing in

[4] Panel cointegration tests have been proposed in the econometric literature, each with their strengths and weaknesses. The tests can be classified into 'first-generation' and 'second-generation' tests, the latter incorporating cross-sectional dependence which the former ignores. See, *inter alia*, Eberhardt (2011) for a detailed review.

countries with weak political and tax systems. Typically, political systems in most developing countries place few constraints (checks and balances) on the power of the executive, and non-state actors, because they do not pay much in taxes (huge informal sectors may suggest that they pay much less taxes) and are unable to control and limit elites' access to resources. Such political systems are less transparent and political elites easily evade taxes and bend tax rules in their favour (Riccuiti, Savoia and Sen, 2016; Besley and Persson, 2014). Regarding the costs of autonomy; to the extent that recipients meet the policy reform conditions stipulated to them by donors when disbursing aid; and there is evidence to suggest that *met* revenue in donor-supported programs either increases tax/GDP ratios (Crivelli and Gupta, 2016) or mitigates the negative effects of aid on taxes (Crivelli and Gupta, 2017), recipients cede less policy influence to donors. This suggests the costs of autonomy for recipients, relating to aid dependence, have reduced.

The bureaucratic costs of aid are also higher than those of tax. Moore (2014) and Fossat and Bua (2013) document fiscal reforms in Anglophone and Francophone Africa, respectively, with many other developing countries implementing reforms and improving tax administration in the last decade. These reforms reduce the bureaucratic costs of taxation, while also increasing the efficiency of tax collection. Contrarily, the bureaucratic costs of aid are still high. This is exacerbated by donor fragmentation, and the emergence of novel donors with changing requirements for aid allocation and monitoring. The evidence, based on our analysis, suggests that the political calculus has shifted in favour of taxation.

5.3 Exploratory analysis

We explore, further, the relationship between aid and taxes. We rely on dummy variables to group countries with similar characteristics, and explore heterogeneity using proxy variables typically used in the tax performance literature.

5.3.1 Level of development

The sample is split into two income groups- least developed countries (LDCs) and other low-income incomes (LICs) - based on the World Bank's income classification (see appendix table A6), to further explore the heterogeneous effects of aid on tax/GDP ratios across different levels of development. Results are reported in Table 3. There is a long-run and short-run positive association between the aid/GDP and tax/GDP ratios. The low tax/GDP ratios in these LDCs point to deep-rooted difficulties in increasing revenues, which include a mixture of structural features of the economy (underdevelopment of information technology, low *per capita* GDP, share of agriculture in GDP and informality, underdevelopment of the corporate sector), administrative (paucity of tax practitioners and accounting professionals, overcomplexity of tax systems) and political constraints (vested interests of elite groups, many tax incentives).

Table 3: Heterogeneity in levels of development

	LDCs	**LICs**
Long-Run		
Aid/GDP	0.125**	0.048
	[0.051]	[0.031]
Short-Run		
Aid/GDP	0.046**	-0.003
	[0.023]	[0.013]
EC Coefficient		
y_{it-1}	-0.505***	-0.487***
	[0.047]	[0.041]
t-statistic	-10.74	-11.75
Diagnostics		
RMSE	0.113	0.069
Stationarity ד	I(0)	I(0)
CD test	-0.76	-0.65
(p-value)	(0.447)	(0.515)
Observations (N)	1078 (38)	1293 (46)

Notes: LDCs refer to least developed countries and LICs refer to other low-income countries. Error correction models are estimated for each region; with the first difference of log (tax/GDP) as dependent variable. For all other details see Table 2.

Source: Author's calculations.

However, increases in the aid/GDP ratio in LDCs will plausibly be associated with long-term increases in the tax/GDP ratio; as confirmed by the results from Table 3. This can be achieved through improvements in revenue administration and broadening the revenue base by creating efficient taxation in the informal sector. Additionally, the evidence from Table 2 suggests that the political calculus may have shifted in favour taxes, with a tendency for governments to increase domestic revenue than accept aid as the political costs of aid are higher. Developing countries are still aid dependent because they are constrained in their abilities to raise taxes (Keen and Simone, 2004), but our line of argument implies that they would prefer increasing domestic revenue to aid.

5.3.2 Region

From table 1B, there are clear differences in the average aid/GDP ratio across regions; with SSA receiving more aid on average than the other three regions. SSA countries also have the lowest tax/GDP ratio than other regions, making it interesting to see if there is a heterogeneous association between aid and taxes across regions. For that purpose, the sample is split into four regions: Sub-Saharan Africa (SSA), Latin America and the Caribbean's (LAC), Asia and the Pacific (AsiaPAC) and the Middle East and North Africa (MENA). Results are presented in Table 4. There is evidence of a long-run and short-run positive association between the aid/GDP and tax/GDP ratios in the SSA region only, with no discernible relationship between aid and taxes for the other three regions. 31 of the 38 LDCs are SSA countries so this finding is not surprising.

Table 4: Heterogeneity across regions

	SSA	LAC	MENA	AsiaPAC
Long-Run				
Aid/GDP	0.119***	0.040	-0.0211	0.051
	[0.043]	[0.053]	[0.092]	[0.059]
Short-Run				
Aid/GDP	0.040*	0.004	0.002	-0.022
	[0.022]	[0.025]	[0.020]	[0.016]
EC Coefficient				
y_{it-1}	-0.531***	-0.484***	-0.378**	-0.452***
	[0.042]	[0.067]	[0.188]	[0.066]
t-statistic	-12.71	-7.27	-2.01	-6.84
Diagnostics				
RMSE	0.106	0.060	0.074	0.091
Stationarity ד	I(0)	I(0)	I(0)	I(0)
CD test	-1.45	1.82	-0.25	0.72
(p-value)	(0.148)	(0.069)	(0.805)	(0.472)
Observations (N)	1161 (40)	512 (19)	174 (6)	501 (18)

Notes: The sample is disaggregated into four regions. SSA stands for Sub-Saharan Africa, MENA for Middle East and North Africa, AsiaPAC for Asia and the Pacific, and LAC for Latin America and the Caribbean's. Error correction models are estimated for each region; with the first difference of log (tax/GDP) as dependent variable. For all other details see Table 2.

Source: Author's calculations.

The challenges low-income countries face in increasing domestic revenue (see the introduction and sub-section 5.3.1) are particularly rife in Sub-Saharan Africa. For most SSA countries political constraints to revenue mobilization are as severe as economic constraints: low political support from top officials for revenue reform; huge turnover of those in managerial positions (usually resulting in the 'death' of fledging reforms); high dependence on foreign aid and natural resources; endemic corruption; tax exemptions and tax expenditures; the influence of interest group politics (Junquera-Varela *et al.,* 2017; Fossat and Bua, 2013; Moore, 2013). These are countries with huge potential for increases in tax/GDP ratios, hence countries in which increases in the aid/GDP ratio will be associated with increases in the tax/GDP ratio. Overcoming political constraints is more difficult because reforms are difficult to implement and sustain since politicians often view them as intrusive. Accordingly, donors can pursue a strategy to support effective reform and alter politicians' preferences, based on the two following components. First, demonstrate benefits of promoting fiscal autonomy, such as increased independence of policy choices and more flexibility in negotiating conditionality with other donors. Second, contribute to creating transparent and sustainable tax systems with broader state-building benefits to the recipients. Increasing domestic revenue supports responsiveness (government's ability to spend on public goods and services that improve the welfare of its citizens) and accountability. This fosters fiscal systems with checks and balances on the executive, strengthening the social contract between the government (through the provision of public goods and services) and the public (through the taxes they pay, and their willingness to pay).

5.3.3 Heterogeneity in aid flows

We estimate the heterogeneous effects of grants, loans and technical assistance on the tax/GDP ratio. Accordingly, we re-estimate equation (3) with respectively, grants (column 1), loans (column 2) and technical assistance (column 3) as the measure of aid and report the results in Table 5. Grants have a long-run positive association with tax/GDP ratios in recipient countries, while loans have no effect on tax/GDP ratios. A plausible explanation for this is the costs of accountability, for both the donors and recipients, are likely to be higher for grants than for loans. For donors, it is easier to justify to their governments and parliaments, the disbursement of a loan than a grant; the straightforward reason being that loans come with obligations of repayment and servicing while grants are seen as 'free' money. Thus, donors place more stringent policies to monitor their aid grants and minimize fungible use. For recipients,

they will have to account to the donors how the grants they disbursed are being spent. These accountability costs also lead to increases in costs of autonomy for the recipient, as they will have to expend effort to circumvent those donor-installed monitoring policies, as well as cede some policy influence to donors.

Table 5: Heterogeneity in aid flows

	Grants	**Loans**	**Technical Assistance**
Additional covariate(s) †			*gdppc*
Long-Run			
Aid/GDP	0.058***	0.010	0.077**
	[0.018]	[0.018]	[0.039]
Short-Run			
Aid/GDP	0.013	0.0007	0.015
	[0.008]	[0.007]	[0.018]
EC Coefficient			
y_{it-1}	-0.521***	-0.517***	-0.503***
	[0.029]	[0.026]	[0.034]
t-statistic	-17.81	-19.66	-14.98
Diagnostics			
RMSE	0.092	0.089	0.085
Stationarity ┐	I(0)	I(0)	I(0)
CD test	-0.07	-1.60	-1.64
(p-value)	(0.940)	(0.110)	(0.102)
Observations (N)	2414 (84)	2328 (84)	2412 (84)

Notes: Error correction models are estimated for all 84 countries in the sample; first with grants/GDP as the aid variable of interest (column 1), then loans/GDP (column 2), and finally technical co-operation/GDP (column 3). The CCEMG with two lags of cross-section averages is used for estimation. † The CCEMG estimator is implemented with two lags of cross-section averages and cross-section averages of other variables (gdppc – GDP *per capita* in constant $2010 values, in logs) as indicated – see main text for details. For all other details see Table 2.

Source: Author's calculations.

When technical assistance is used as a measure of aid, cross-section correlation is not entirely wiped out from equation 3. Technical assistance is a form of aid that may not be given in response to specific characteristics of a recipient country. Thus, while the absolute amount of technical assistance varies across countries, the purpose for disbursing it is broadly similar across countries. This creates pervasive cross-section correlations across countries with respect to technical assistance. Hence, in addition to the lags of cross-section averages, cross-section (and their lags) averages of GDP *per capita* are included to wipe out cross-section correlation (see section 4.1). Technical assistance has a long-run positive association with tax/GDP ratios. Such technical assistance has the potential to relax capacity constraints in tax administration and policy, as well as increase tax collection efficiency without necessarily increasing tax rates; thereby reducing the bureaucratic costs of taxation. Due to the persistence of tax/GDP ratios such improvements are mostly medium to long-term; corresponding to the long-run positive association between the aid/GDP and tax/GDP ratios.

5.3.4 Domestic revenue

Royalties, taxes and other revenue from natural resources are important in countries endowed with natural resources. Thus, we re-estimate equation (5) with two new measures of revenue; total tax revenue and total government revenue.

Table 6: Heterogeneity in domestic revenue

	Total Tax Revenue	Total Domestic Revenue
Additional covariates ٦	*gdppc, agriculture*	
Long-Run		
Aid/GDP	0.080***	0.052**
	[0.026]	[0.021]
Short-Run		
Aid/GDP	0.012	-0.003
	[0.012]	[0.010]
EC Coefficient		
y_{it-1}	-0.548***	-0.539***
	[0.036]	[0.032]
t-statistic	-15.16	-16.64
Diagnostics		
RMSE	0.083	0.091
Stationarity ٦	I(0)	I(0)
CD test	-1.47	-1.40
(p-value)	(0.143)	(0.162)
Observations	2374 (84)	2343 (83)

Notes: 'Total Tax Revenue' and 'Total Domestic Revenue' refer to error correction models for all 84 countries first with total tax revenue (including natural resource taxes) as the measure of domestic revenue (column 1), then total government revenue as the measure of domestic revenue (column 2). ٦ The CCEMG estimator is implemented with two lags of cross-section averages and cross-section averages of other variables (gdppc – GDP *per capita* in constant $2010 values; agriculture – the share of agriculture value added in GDP, all in logs) as indicated – see main text for details. For all other details see Table 2.

Source: Author's Calculations

The former comprises revenue from non-resource and resource taxes (both direct and indirect tax components), while the latter is a composite of tax and non-tax revenues. Including lags of cross-section averages does not completely expunge the cross-section correlation present in total tax revenue. Total tax revenue is shaped by entrenched historical factors, some of which include indigenous colonial heritage (Mkandawire, 2010). Hence, countries that share colonizers will plausibly have similar tax systems. In addition, taxation reforms, introduction of the VAT, pervasive trade liberalization in developing countries have been carried out broadly around the same time (from the 1980s to the early 2000s). This results in strong correlations in total tax revenues across countries. Thus, in addition to the lags of cross-section averages, cross-section (and their lags) averages of GDP *per capita* and the share of agriculture value added in GDP are included to expunge cross-section correlation (see section 4.1).

Results are reported in Table 6 above. Regarding total tax revenue (column 1), the results do not differ so much to those with non-resource taxes as the measure of domestic revenue. There is a positive long-run relationship between the aid/GDP and the (total) tax/GDP ratios. Regarding total government revenue (column 2), the coefficient on the aid/GDP ratio is relatively smaller. This is to be expected as total domestic revenue comprises non-tax revenue (which includes natural resources), and theory is not predictive on how aid can affect such non-tax revenue. It is possible that the smaller effect shows aid having a positive association with the non-resource tax revenue component of total government revenue.

5.3.5 Donor conditionality

In line with the argument in section 2 we test if there is a role for revenue conditionality in improving tax/GDP ratios. Data on revenue conditionality in IMF-supported programs is obtainable from the IMF's Monitoring of Fund Arrangements (MONA) database; following Crivelli and Gupta (2016, 2017). In choosing the economic descriptors for conditionality in the MONA database, we focus on those related to revenue conditionality: specifically, revenue measures and revenue administration. From these descriptors, only "met" revenue conditionality was considered. Thus, we create a dummy variable which

takes the value 1 for all countries in the 'dropdown' dataset (those with revenue conditionality) and zero otherwise. Results are presented in Table 7.

There is evidence of a positive long-run association between aid/GDP and tax/GDP ratios in countries with *met* revenue conditionality. This long-run effect reflects the all-encompassing nature of revenue conditionality, including quantitative (for example, observable targets like increasing the VAT rate) as well as structural (for example, statutory aspects of tax reform like submitting legislations to parliament) conditionality. There is also evidence of a positive short-run relationship between aid/GDP and tax/GDP ratios, most likely reflected through quantitative revenue conditionality in which the effects plausibly take less time to be observed. This would also suggest that the political calculus, based on costs of autonomy, is in favour of taxes. Countries that meet revenue conditions in IMF and other donor-supported programs will have the ability to make independent policy choices, thereby reducing the political costs of autonomy.

Table 7: Revenue conditionality

	Revenue Conditionality	**No Revenue Conditionality**
Long-Run		
Aid/GDP	0.119***	-0.006
	[0.039]	[0.032]
Short-Run		
Aid/GDP	0.032**	-0.020
	[0.016]	[0.015]
EC Coefficient		
y_{it-1}	-0.483***	-0.519***
	[0.042]	[0.043]
t-statistic	-11.50	-12.02
Diagnostics		
RMSE	0.089	0.097
Stationarity ϯ	I(0)	I(0)
CD test	0.34	-0.69
(p-value)	(0.731)	(0.493)
Observations (N)	1539 (54)	830 (30)

Notes: 'Revenue Conditionality' refers to countries with met revenue conditionality (either quantitative or structural) in IMF-supported programs while 'No Revenue Conditionality' refers to the rest of the countries in the sample. The CCEMG with two lags of cross-section averages is used. For all other details see Table 2.

Source: Author's calculations.

5.3.6 Recipient policy reform

To capture the policy effects of aid on tax/GDP ratios we focus on the creation and operation of Semi-Autonomous Revenue Authorities (SARAs hereafter). Evidence on the effectiveness of SARAs is mixed. The benefit of having such authorities is that tax collection is handled by an independent agency (which receives performance incentives). Ideally, the effectiveness of SARAs in improving revenue performance should reduce the accountability costs of taxes in recipient countries. Indeed Ahlerup, Baskaran and Bigsten (2015), using data for 47 countries from 1980–2010, provide evidence that SARAs in Sub-Saharan Africa have been associated with at least short-term increases in tax revenue (the effects usually subside after about 5 years). A weakness of SARAs is that governments (politicians) still retain control over tax policy design and can still favour select groups by granting tax exemptions. In addition, the effectiveness of SARAs depends on domestic political and economic events; with political instability and adverse economic developments undermining the positive aspects of reform. Furthermore, as politicians retain control over tax policy in developing countries, the countries are still subject to political budget cycles (Brender and Drazen, 2005; Shi and Svensson, 2006); which is exacerbated by the weak nature of tax institutions (lack of transparency and accountability). Dom (2017), using data for 46 SSA countries from 1980-2012, suggests that there is no observable effect of SARAs on revenue collection.

Table 8(a): Recipient policy reform

	Revenue Authority	No Revenue Authority
Long-Run		
Aid/GDP	0.044	0.090***
	[0.049]	[0.033]
Short-Run		
Aid/GDP	0.015	0.011
	[0.031]	[0.013]
EC Coefficient		
y_{it-1}	-0.502***	-0.494***
	[0.048]	[0.040]
t-statistic	-10.36	-12.50
Diagnostics		
RMSE	0.083	0.095
Stationarity ד	I(0)	I(0)
CD test	0.42	-1.49
(p-value)	(0.673)	(0.135)
Observations (N)	715 (25)	1656 (59)

Notes: 'Revenue Authority' comprises countries with operational semi-autonomous revenue authorities, while 'No Revenue Authority' refers to the rest of the countries in the sample. The CCEMG with two lags of cross-section averages is used. For all other details see Table 2.

Source: Author's calculations.

Following the tax performance literature, we disaggregate countries based on the presence of an operational semi-autonomous revenue authority in the country, and re-estimate equation (5) for both groups of countries; results from which are in Table 8(a). We find that for countries with SARAs there is no observable long-run (or even short-run) relationship between the aid/GDP and tax/GDP ratios. For countries without SARAs, we find a strong positive long-run relationship between the ratios. As already mentioned the effectiveness of SARAs depends a lot on dynamic political and economic factors, which are typically country-specific. Tax administration and policy has improved over the years (Moore, 2014; Fossat and Bua, 2013) and tax ratios have also increased gradually, but most developing countries are still subject to political and economic instability, thereby undermining the efforts of reform (see Ahlerup *et al.,* 2015 for country-specific evidence on the effectiveness of SARAs).

It is also possible that technical assistance subsumes the effect of reform, such that any positive effects of SARA reform are being captured by the positive long-run impact of technical assistance. This last argument is tested by re-estimating equation (5) for the SARA and non-SARA groups using technical assistance as the measure of aid (see Table 8(b)). We find evidence of a positive long-run relationship between technical assistance and tax/GDP ratios for countries with revenue authorities. This is to be expected since technical assistance is given to countries to help implement fiscal reforms involving tax administration and establishing independent revenue authorities. This finding implies that the effectiveness of SARAs depends as much on technical assistance from donors as domestic factors.

Table 8(b): Recipient policy reform

	Revenue Authority	No Revenue Authority
Long-Run		
Aid/GDP	0.104*	0.065
	[0.052]	[0.054]
Short-Run		
Aid/GDP	0.034	0.007
	[0.034]	[0.021]
EC Coefficient		
y_{it-1}	-0.518***	-0.496***
	[0.052]	[0.043]
t-statistic	-9.86	-11.62
Diagnostics		
RMSE	0.078	0.088
Stationarity ד	I(0)	I(0)
CD test	1.04	0.01
(p-value)	(0.300)	(0.993)
Observations (N)	726 (25)	1689 (59)

Notes: 'Revenue Authority' comprises countries with operational semi-autonomous revenue authorities, while 'No Revenue Authority' refers to the rest of the countries in the sample. The aid/GDP ratio used here is 'technical assistance-to-GDP ratio'. The CCEMG with two lags of cross-section averages is used. For all other details see Table 2.

Source: Author's calculations.

5.3.7 Stability of donor-recipient relationships

Here we classify countries according to the volatility of their aid. If the level of aid is highly unpredictable from one year to the next, aid may be too unpredictable for fiscal planning, worsening revenue performance in developing countries. Furthermore, such unpredictability may offset any possible impact aid would have on the tax/GDP ratio, with the net effect being nil. Alternatively, highly unpredictable aid may also strengthen the need for increased domestic revenue mobilization (see section 2.1).

We estimate two measures of aid volatility; one intended to capture uncertainty while the other is a measure of instability. Aid uncertainty can be defined as the unanticipated variability in the aid/GDP resulting from macroeconomic uncertainty. It is measured by the standard deviation of the residuals of a forecasting regression (an $AR\ (2)$ process) of the aid/GDP to determine the expected component of the aid/GDP ratio. The forecasting equation is as follows:

$$aid_{it} = \gamma + \alpha_{i1} aid_{it-1} + \alpha_{i2} aid_{it-2} + e \qquad (8)$$

where aid_{it} is net aid as a percentage of GDP, γ is a constant term and e is an error term with standard properties. We classify countries with high aid uncertainty as those with a standard deviation greater than 0.3, with the rest of the sample representing countries with low aid uncertainty.

Table 9(a): Heterogeneity in aid uncertainty

	High Aid Uncertainty	Low Aid Uncertainty
Long-Run		
Aid/GDP	0.032	0.155***
	[0.028]	[0.053]
Short-Run		
Aid/GDP	0.014	0.026
	[0.013]	[0.022]
EC Coefficient		
y_{it-1}	-0.479***	-0.502***
	[0.046]	[0.040]
t-statistic	-10.71	-12.39
Diagnostics		
RMSE	0.097	0.085
Stationarity ד	I(0)	I(0)
CD test	-1.04	0.78
(p-value)	(0.299)	(0.436)
Observations (N)	1302 (47)	1069 (37)

Notes: 'Aid Uncertainty' is defined as the unexpected variability in aid because of macroeconomic shocks. It is measured as the standard deviation of the residuals from a forecasting equation (an AR (2) process) to determine the expected component of aid/GDP. In our classification, countries with high aid uncertainty are those for which said standard deviation is greater than 0.3, and low aid uncertainty countries represent the rest of the countries in the sample. For all other details see table 2.

Source: Author's calculations.

The second measure of volatility is the coefficient of variation (CoV) of the logged aid/GDP ratio; measured as a ratio of the standard deviation of the aid/GDP series to the mean value of the series over time. Morrissey and Osei (2004) state that this is a measure of general instability of aid (a result of donor difficulties) over the period. We classify countries with high aid instability as those with the coefficient of variation greater than 0.6, with the rest of the sample representing countries with low aid instability. Results for both measures of aid volatility are reported in Tables 9(a) and (b).

For countries with high aid uncertainty, there is no discernible effect of the aid/GDP ratio on the tax/GDP ratio. This confirms the assertion that high year-on-year variability in aid may offset any potential effects aid has on tax revenue. In countries with low aid uncertainty there is a positive long-run relationship between aid/GDP and tax/GDP ratios. The less donors deviate from their aid commitments, the more predictable aid flows will be and in such countries, aid has a positive long-run association with taxes. For countries with high aid instability, there is no observable relationship between the aid/GDP and tax/GDP ratios. For countries with low aid instability, there is a positive long-run relationship between the aid/GDP.

Table 9(b): Heterogeneity in aid instability

	High Aid Instability	Low Aid Instability
Long-Run		
Aid/GDP	0.033	0.119***
	[0.031]	[0.043]
Short-Run		
Aid/GDP	0.011	0.019
	[0.014]	[0.018]
EC Coefficient		
y_{it-1}	-0.513***	-0.475***
	[0.053]	[0.037]
t-statistic	-9.74	-13.00
Diagnostics		
RMSE	0.096	0.088
Stationarity ד	I(0)	I(0)
CD test	0.01	0.80
(p-value)	(0.989)	(0.422)
Observations (N)	1042 (38)	1329 (46)

Notes: 'Aid Instability' is defined as the year-on-year variation in the aid/GDP and tax/GDP ratios in developing countries; with the coefficient of variation (the standard deviation of the variable series as a percentage of the mean value for the series) used as a measure of instability. In our classification, countries with high aid instability are those with a coefficient of variation greater than 0.6 and the rest of the sample make up those with low aid instability. For all other details see Table 2.

Source: Author's calculations.

5.3.8 Heterogeneity by natural resource wealth

Countries with natural resources may be less inclined to raise domestic revenue through taxes; the decision-makers would not want to 'burden' their citizens with unpopular taxes when they can raise funds through their natural endowments. In a similar vein, the availability of natural resources may reduce the need for aid as recipients are more likely to raise domestic revenues if they want control over how funds are being used (Morrissey, 2015). This is because aid is subject to conditionality, and resource revenues are more accessible and fungible: the revenue is obtained independently of the government's effort and a huge chunk of the proceeds from natural resource extraction goes to the state (von Haldenwang and Ivanyna, 2017). Thus, for countries with natural resources the accountability costs of taxation will be lower than the accountability of aid such that recipient governments do not necessarily prefer aid to tax; or that they would substitute aid for tax, with the net effect of aid on taxes unchanged (empirically, this will be reflected by an insignificant relationship between aid and taxes).

We distinguish resource rich (RR) from non-resource rich (NRR) countries, the classification based on the Cottarelli (2012) categorization; with the former comprising countries are mineral and petroleum (oil, gas) producers.[5] For countries with natural resource wealth, aid has no effect on tax/GDP ratios while for those without natural resources the aid/GDP ratio has a long-run positive impact on the tax/GDP ratio. The absence of a significant long-run impact can be attributed to the costs of autonomy: countries with natural resources typically receive less aid[6] than their non-resource rich counterparts, thus are able to make independent policy decisions.

[5] The mining countries include: Botswana, Chile, Colombia, Democratic Republic of Congo, Ghana, Guinea, Indonesia, Lesotho, Mauritania, Papua New Guinea, Sierra Leone, Tanzania. The petroleum countries include: Algeria, Angola, Cameroon, Chad, Colombia, Congo Republic, Democratic Republic of Congo, Cote d'Ivoire, Ecuador, Equatorial Guinea, Indonesia, Iran, Mauritania, Mexico, Niger, Papua New Guinea, Philippines, Sudan, Venezuela.

[6] Some of these countries are LDCs (for example, Tanzania, Chad, Niger and Sudan), thus they receive high amounts of aid. Nevertheless, the average resource rich country receives less aid than its non-resource rich counterpart.

Table 10: Heterogeneity in natural resource wealth

	Natural Resources	No Natural Resources
Long-Run		
Aid/GDP	0.073	0.079**
	[0.056]	[0.032]
Short-Run		
Aid/GDP	0.026	0.011
	[0.028]	[0.013]
EC Coefficient		
y_{it-1}	-0.540***	-0.473***
	[0.062]	[0.035]
t-statistic	-8.77	-13.62
Diagnostics		
RMSE	0.104	0.086
Stationarity ٦	I(0)	I(0)
CD test	-0.86	-0.82
(p-value)	(0.399)	(0.415)
Observations (N)	719 (26)	1652 (58)

Notes: 'Natural Resources' includes resource-rich countries with active extractive industries; oil, gas and mining as classified in IMF (2012) while 'No Natural Resources' includes non-resource-rich countries. For all other details see Table 2.

Source: Author's calculations.

5.4 Endogeneity and long-run causality

In table 11 we present results for weak exogeneity tests; using specifications of equations (6) and (7) with two lags. The results are based on the dynamic CCEMG model augmented with two lags of cross-section averages (this is the long-run relationship from which the disequilibrium term is constructed). In each row with 'equation', the specified variable is used as dependent variable in the ECM regression. We also report the panel robust $\hat{\theta}_i$ estimate, which exists only for the group-mean tests (Canning and Pedroni, 2008), and its associated t-statistic. We would expect a typically high t-statistic on the average $\hat{\theta}_i$ coefficients in the tax equations (which can be interpreted as evidence of a long-run causal relationship from aid to taxes) and a low t-statistic (below 1.96) in the aid equations (Eberhardt and Presbitero, 2015). In the last column, we report the share of countries in the sample (N_i/N) that fail to reject the null of 'no causal' impact.

In examining the details of Table 11, the first clear pattern is that both the GM and Fisher statistics consistently fail to reject the null of 'no causal impact'. In addition, the share of countries that fail to reject the null of 'no causal impact' from aid to tax is uniformly low across alternative specifications, typically below 40%. This provides strong evidence in favour of a long-run causal relationship from aid/GDP to tax/GDP ratios, across different measures of aid and varying degrees of heterogeneity. The results conform to the statutory nature of tax systems such that tax policy, once implemented, is not easily reversed in the short-run. Hence changes in the level of aid induce permanent changes in the level of taxation.

With regard to the ECM specifications with aid as dependent variable, the results have five characteristic features. First, we cannot reject the null that tax/GDP ratios have a zero-average long-run impact on aid/GDP ratios; for the baseline estimates (the main behavioural representation from table 2) and across various degrees of heterogeneity. However, for the baseline estimates, we can conclude that the long-run impact of taxes on aid is not pervasively zero; such that changes in tax/GDP ratios may induce changes in the aid/GDP ratio in some, but not all countries. Furthermore 79% of countries fail to reject the null of 'no causal impact', suggesting that aid is potentially weakly exogenous. While aid is important for long-run taxation behaviour in developing countries (fiscal planners have expectations for aid as commitments

are known in advance), the level of aid is independent of revenue performance in recipient countries. Second, grants are strongly weakly exogenous but *long-run forcing*; as they have a significant long-run impact on tax/GDP ratios. Accounting for the contemporaneous correlation between high grants and low tax-to-GDP ratios (through the heterogeneous ECM), we find that in the long-run the level of grants is independent of revenue performance in recipient countries.

Third, technical assistance is weakly exogenous, which is intuitive. As this is a measure of off-budget aid it is determined irrespective of the recipients' revenue and/or growth characteristics but it has a long-term beneficial impact on tax/GDP ratios. We also test for weak exogeneity of technical assistance for countries with revenue authorities (as technical support is given for tax administration and policy design, typical activities carried out by revenue authorities). Again, technical assistance is found to be weakly exogenous; such that tax/GDP ratios have a zero-average long-run impact on technical assistance in countries with revenue authorities, and changes in technical assistance induce permanent changes in taxes in those countries. Fourth, reverse causality may be associated with revenue conditionality; such that countries with macroeconomic and structural weaknesses – reflected by low tax/GDP ratios- may request for IMF (and other donor-) support to improve their fiscal situation. As seen from Table 11, we are confident that our results for donor conditionality are not driven by reverse causality. Long-run causation is uni-directional, from aid/GDP to tax/GDP and not vice-versa. Fifth, for countries with low aid volatility (low aid uncertainty and instability), long-run causation runs from the aid/GDP to the tax/GDP ratio.

Ultimately, given the data dimensions and characteristics, and given all the problems and caveats of individual country and panel exogeneity tests, we suggest most conservatively that long-run causation runs mainly from aid/GDP to tax/GDP ratios; with aid (and its components) being weakly exogenous. There is no 'donor disbursement rule' in which recipients' revenue performance influences the level of aid received.

Table 11: Weak exogeneity tests

	GM	(p)	Fisher	(p)	Mean $\hat{\theta}_i$	t-stat	N_i/N
Baseline Estimates							
Tax Equation	-1.974	0.048	639.52	0.000	-0.493	-12.766	38%
Aid Equation	-0.124	0.901	212.12	0.012	-0.109	-1.044	79%
Heterogeneous Aid (1)							
Tax Equation	-2.114	0.034	668.827	0.000	-0.556	-15.044	33%
Grants Equation	-0.040	0.968	172.633	0.387	-0.080	-0.564	86%
Heterogeneous Aid (2)							
Tax Equation	-2.085	0.037	686.019	0.000	-0.586	-14.293	33%
Technical Assistance Equation	-0.089	0.929	189.240	0.125	-0.094	-1.214	87%
Donor Conditionality							
Tax Equation	-1.827	0.068	373.22	0.000	-0.448	-9.192	40%
Aid Equation	-0.288	0.774	135.26	0.040	-0.227	-2.059	80%
No Recipient Reform							
Tax Equation	-1.971	0.049	449.058	0.000	-0.467	-9.802	39%
Aid Equation	-0.275	0.783	147.025	0.036	-0.190	-1.503	76%
Recipient Reform[7]							
Tax Equation	-2.160	0.031	220.733	0.000	-0.676	-12.144	16%
TA Equation	-0.409	0.683	53.073	0.357	-0.280	-1.690	88%
LDCs							
Tax Equation	-2.057	0.040	307.660	0.000	-0.495	-8.312	37%
Aid Equation	-0.293	0.770	103.093	0.021	-0.204	-1.830	79%
Sub-Saharan Africa							
Tax Equation	-2.050	0.040	311.46	0.000	-0.535	-9.826	33%
Aid Equation	-0.278	0.781	91.361	0.181	-0.238	-2.149	85%
No Natural Resources							
Tax Equation	-2.024	0.043	477.460	0.000	-0.466	-9.878	40%
Aid Equation	-0.198	0.843	143.265	0.044	-0.206	-1.721	78%
Low Aid Uncertainty							
Tax Equation	-1.882	0.060	472.62	0.000	-0.464	-10.526	46%
Aid Equation	-0.022	0.983	148.42	0.105	-0.095	-0.737	84%
Low Aid Instability							
Tax Equation	-2.061	0.039	366.948	0.000	-0.465	-10.706	37%
Aid Equation	-0.133	0.894	90.496	0.525	-0.134	-1.328	83%

Notes: (i) TA is technical assistance.(ii) We report results only for significant long-run impacts from tables 2 to 10. We report both statistics developed by Canning and Pedroni (2008). GM denotes the group-mean statistic which is the average of country-specific t-ratios on the disequilibrium term which is distributed $\mathrm{N}(0,1)$. Fisher is $-2\sum_{\mathrm{i}=1}^{\mathrm{N}}\ln\Pi$, where Π is the p-value of the country-specific t-value on the disequilibrium term. The Fisher statistic is distributed $\chi^2(2\mathrm{N})$. Both test statistics are for the null of 'no causal impact' which in our case can be interpreted as the variable not adjusting to maintain fiscal equilibrium. We also report the robust $\hat{\theta}_{\mathrm{i}}$ estimate, and its associated t-statistic. In the last column, we report the percentage of countries in the sample that fail to reject the null of 'no causal' impact. Source: Author's calculations.

[7] This is based on table 8(b), in which the measure of aid is technical assistance

6 Conclusion and discussion

This paper first examined the relationship between aid and taxes using heterogeneous (panel) time-series techniques to deal with problems creating dissension in cross-country aid-tax research: neglecting long-run levels relationships between aid and tax ratios (a result of persistence in fiscal data), measurement of aid and revenue in a way that captures behavioural effects, heterogeneity, endogeneity, cross-country correlation and causality between aid and taxes. Using data for 84 developing countries over the period 1980 to 2013, we find that aid and taxes comprise a long-run (equilibrium) cointegrated relation. Estimates show that on average, aid has a positive long run association with taxes and the effect is robust to outliers and empirical specification. The positive long-run relationship is also robust to sample selection, with an observed effect in least developed countries and countries in Sub-Saharan Africa. The effect of aid on tax reflects a revenue choice that differs across countries based on political economy factors, which donors may influence through technical support and conditionality, over which source of revenue meets government objectives (Morrissey, 2015). Thus, our findings are consistent with the argument in section 2 that the political calculus may have shifted in favour of taxes, such that recipients prefer increasing taxes instead of depending on aid since the political costs of aid are higher.

Correlations between aid and taxes have been mistaken for causation in the revenue (tax) performance literature, and empirical evidence may suggest that aid (especially in the form of grants) discourages tax effort. Given the structure of the economy (low tax bases created, in part, by high informal and subsistence agricultural sectors), aid goes to countries with *ex ante* lower income levels (hence lower tax/GDP ratios and higher need), independent of their tax effort (or implied lack thereof). Sceptics, backed by cross-country empirical evidence, point to this contemporaneous correlation as aid having a behavioural effect on tax effort (with this perceived effect stronger for lower income countries based on the argument above). As countries experience growth, one typically observes a corresponding increase in the tax base (increases in income levels with increases in tax revenues) and a decline in the level of aid (as the need for aid decreases). Using an ECM allows this negative contemporaneous correlation between aid and taxes to be accounted for by distinguishing the short-run from the long-run (the period by which aid might have any behavioural effects on taxes); and the evidence points to a positive long-run association between aid and taxes.

The importance of aid heterogeneity, with different effects for grants and loans, is confirmed in this study. The argument that aid grants tend to reduce effort while aid loans encourage tax effort is tenuous: there are associations between aid and tax in the data, largely due to structural characteristics of the economy whereby high aid receipts (especially in the form of grants) are associated with determinants of tax revenue. In this paper we find that grants are associated with increased tax/GDP ratios while loans have no impact on taxes. We argue that grants are associated with higher costs of accountability than taxes, for both recipients and donors, since they are disbursed with more stringent monitoring mechanisms and conditions. Increased accountability costs translate to increased costs of autonomy (reflected by the absence of autonomy) for the recipient as they have to expend effort in circumventing donors' monitoring mechanisms and conditionality. Technical assistance is particularly crucial in improving revenue performance in developing countries, especially in countries engaged in revenue reform; through improving the design and implementation of tax policy reforms, and improving processes to increase tax collection efficiency. Such technical support from donors will help to reduce the bureaucratic costs of taxation, thereby assisting a transition to increase domestic revenue.

The revenue choice between aid and taxes depends on domestic political economy factors which may also be influenced by donors through aid conditionality; though there are two innate limitations with modelling revenue conditionality in aid programs: (i) the measure of conditionality is too narrow since it considers only IMF conditionality (see section 2 for an argument for why this is appropriate); and donor

proliferation ensures that they have varying motivations for providing aid. (ii) revenue conditionality changes over the years (countries move across conditionality spectra) and empirical specifications cannot easily account for these transitions. The significance of aid conditionality in improving revenue performance, however, is confirmed in this study. For countries with met revenue conditionality there's a positive association between aid and taxes. This positive relationship can be related to the political costs of autonomy; countries that meet donors' conditions have more leverage in negotiating future conditionality, if any, as well as the ability to make independent policy choices.

Rather than just asking if there is a strong positive relationship between foreign aid (its components, as well as conditions and technical support associated with it) and taxes we can isolate the presence of an effect of aid on taxes while simultaneously controlling for the reverse effect that taxes are likely to have on aid. Across different specifications, we find that causality between aid and taxes is uni-directional; with pervasive evidence for long-run causality from aid to taxes. This underscores the argument that previous research in the area tends to treat correlation as causation.

Understanding the characteristics of aid and taxation data, as well as the relationship between aid, donors and taxation informs the appropriate analytical method. Given that cross-country heterogeneity is pervasive and entrenched, aid and tax data are characterized by persistence, and the need to distinguish long-run (equilibrium) from short-run dynamics an error correction model representation is appropriate. An added advantage of the ECM is it controls for the contemporaneous correlation between aid (and policy 'favourite', grants) and taxes, while allowing for an agnostic, albeit long timeframe within which aid can influence taxes. Once these salient features are incorporated into econometric specifications, results might be consistent across different data sources.

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Appendix Table A1: Cross-section dependence

Panel A	Variables in Levels	
	Tax_{it}	Aid_{it}
avg $\hat{\rho}_{ij}$	0.077	0.247
avg $\lvert\hat{\rho}_{ij}\rvert$	0.405	0.418
CD	12.29	40.29
p-value	0.000	0.000
Panel B	**Variables in First Differences**	
	ΔTax_{it}	ΔAid_{it}
avg $\hat{\rho}_{ij}$	0.003	0.055
avg $\lvert\hat{\rho}_{ij}\rvert$	0.178	0.179
CD	0.27	9.22
p-value	0.784	0.000

Notes: We use the stata routine 'xtcd' developed by Markus Eberhardt. We report the average correlation (avg $\hat{\rho}_{ij}$) and average absolute correlation (avg $|\hat{\rho}_{ij}|$) coefficients of the $N(N-1)$ sets of correlations. CD is the Pesaran (2004) test for cross-section dependence distributed $N(0,1)$ under the null of cross-section independence. Panels A and B test for cross-section dependence in the variable series for levels and first differences respectively. Tax revenue (Tax), Net ODA (Aid): all as percentages of GDP.

Source: Author's calculations.

Appendix Table A2: Pesaran (2007) Unit root test

	Levels: CIPS with intercept only			
Variable	Tax_{it}		Aid_{it}	
Lags	Z*t*bar	*p*	Z*t*bar	*p*
0	-4.58	0.00	-3.89	0.00
1	-3.22	0.00	-1.19	0.12
2	-0.97	0.17	1.03	0.85
3	1.30	0.90	-0.10	0.46
4	2.47	0.99	1.96	0.98
	Levels: CIPS with intercept & trend			
Variable	Tax_{it}		Aid_{it}	
Lags	Z*t*bar	*p*	Z*t*bar	*p*
0	-5.27	0.00	-4.561	0.00
1	-3.97	0.00	-1.84	0.03
2	-2.29	0.01	1.22	0.89
3	1.00	0.84	-0.03	0.49
4	2.46	0.99	1.19	0.88
	Differences: CIPS test with drift			
Variable	ΔTax_{it}		ΔAid_{it}	
Lags	Z*t*bar	*p*	Z*t*bar	*p*
0	-24.63	0.00	-26.48	0.00
1	-15.76	0.00	-16.29	0.00
2	-10.75	0.00	-7.89	0.00
3	-4.99	0.00	-5.95	0.00
4	-2.91	0.00	-4.14	0.00

Notes: Lags' denote the number of lags of the differenced dependent variable included to wipe out serial correlation. Tax revenue (Tax), Net ODA (Aid): all as percentages of GDP.

Source: Author's calculations.

Appendix Table A3: Cross-section dependence

Panel A		Variables in Levels			
	Tax_{it}	Aid_{it}	$Grants_{it}$	$Loans_{it}$	TA_{it}
avg $\hat{\rho}_{ij}$	0.121	0.133	0.139	0.268	0.522
avg $\lvert\hat{\rho}_{ij}\rvert$	0.401	0.335	0.354	0.359	0.602
CD	37.71	40.35	43.83	82.15	160.69
p-value	0.000	0.000	0.000	0.000	0.000
Panel B		Variables in First Differences			
	ΔTax_{it}	ΔAid_{it}	$\Delta Grants_{it}$	$\Delta Loans_{it}$	ΔTA_{it}
avg $\hat{\rho}_{ij}$	0.003	0.042	0.036	0.016	0.152
avg $\lvert\hat{\rho}_{ij}\rvert$	0.181	0.178	0.193	0.183	0.223
CD	0.88	13.02	10.95	4.61	45.36
p-value	0.381	0.000	0.000	0.000	0.000

Notes: Tax revenue (Tax), Net ODA (Aid), Grants, Loans and Technical Assistance (TC); all as percentages of GDP. See table A1 for other details.

Source: Author's calculations.

Appendix Table A4: Pesaran (2007) Unit root test

	Levels: CIPS with intercept only									
Variable	Tax		Aid		Grants		Loans		TC	
Lags	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*
0	-4.80	0.00	-8.32	0.00	-11.35	0.00	-12.55	0.00	-4.10	0.00
1	-3.30	0.00	-3.88	0.00	-6.13	0.00	-6.52	0.00	-0.41	0.34
2	-0.90	0.18	-0.74	0.23	-2.71	0.00	-5.34	0.00	-0.08	0.47
3	-0.86	0.20	-0.94	0.17	-1.79	0.04	-4.17	0.00	-0.32	0.38
4	-1.03	0.15	2.00	0.98	2.55	1.00	-2.03	0.02	1.65	0.95
	Levels: CIPS with intercept & trend									
Variable	Tax		Aid		Grants		Loans		TC	
Lags	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*
0	-6.46	0.00	-8.22	0.00	-10.73	0.00	-11.81	0.00	-6.18	0.00
1	-4.79	0.00	-3.70	0.00	-4.72	0.00	-3.56	0.00	-1.66	0.05
2	-1.51	0.07	-0.47	0.32	-1.24	0.11	-1.28	0.10	0.10	0.54
3	0.16	0.56	0.59	0.72	-0.64	0.26	0.40	0.65	0.75	0.77
4	2.19	0.99	4.88	1.00	4.68	1.00	2.10	0.98	3.18	1.00
	Differences: CIPS test with drift									
Variable	Tax		Aid		Grants		Loans		TC	
Lags	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*	*Z*tbar	*p*
0	-34.41	0.00	-37.85	0.00	-40.27	0.00	-39.82	0.00	-39.44	0.00
1	-23.15	0.00	-25.74	0.00	-28.69	0.00	-25.70	0.00	-23.61	0.00
2	-14.45	0.00	-15.57	0.00	-17.11	0.00	-15.08	0.00	-13.54	0.00
3	-8.59	0.00	-11.86	0.00	-14.33	0.00	-10.16	0.00	-11.29	0.00
4	-3.90	0.00	-7.23	0.00	-10.61	0.00	-7.05	0.00	-4.65	0.00

Notes: Net ODA (Aid), technical cooperation (TC), tax revenue (Rev) and government expenditure (Exp) all in logs. 'Lags' denote the number of lags of the differenced dependent variable included to wipe out serial correlation. Tax revenue (Tax), Net ODA (Aid), Grants, Loans and Technical Assistance (TC); all as percentages of GDP.

Source: Author's calculations.

Appendix Table A5

	Grants/GDP	Loans/GDP	TA/GDP		Grants/GDP	Loans/GDP	TA/GDP
Algeria	0.08	0.21	0.16	Madagascar	5.58	4.18	1.96
Angola	1.24	0.56	0.50	Malawi	8.90	3.82	2.47
Argentina	0.01	0.03	0.03	Maldives	1.95	3.34	1.85
Bangladesh	1.11	1.81	0.47	Mali	5.93	4.66	2.93
Belize	1.24	1.72	1.56	Mauritania	8.05	5.83	2.35
Benin	0.21	0.13	0.09	Mauritius	0.46	0.98	0.53
Bhutan	5.22	2.69	4.86	Mexico	0.01	0.03	0.02
Botswana	1.19	0.46	1.31	Morocco	0.56	1.37	0.53
Burkina Faso	6.14	3.56	3.06	Mozambique	11.77	5.98	3.20
Burundi	13.36	5.16	3.82	Nepal	2.65	2.79	2.08
Cameroon	2.08	1.57	0.88	Nicaragua	6.44	3.53	2.14
Cape Verde	8.45	5.07	5.78	Niger	7.46	3.41	3.16
CAR	6.65	2.27	3.01	Pakistan	0.51	1.33	0.27
Chad	4.05	2.66	2.02	Panama	0.20	0.24	0.23
Chile	0.04	0.04	0.11	Papua New Guinea	2.29	0.66	1.44
China	0.02	0.19	0.05	Paraguay	0.24	0.68	0.53
Colombia	0.08	0.08	0.17	Peru	0.26	0.38	0.29
Comoros	6.74	4.77	5.33	Philippines	0.23	0.82	0.31
Congo Rep.	2.78	2.13	1.25	Rwanda	10.73	3.32	3.71
Costa Rica	0.42	0.75	0.46	Sao Tome & Principe	16.23	10.38	10.65
Cote D'Ivoire	2.28	2.25	0.72	Senegal	4.28	3.98	2.73
Dominica	3.18	3.71	1.26	Seychelles	1.50	1.76	1.94
Dominican Republic	0.22	0.43	0.23	Sierra Leone	8.42	4.39	1.96
DRC	5.64	1.22	0.56	Solomon Islands	6.86	2.62	12.77
Ecuador	0.19	0.35	0.32	Sri Lanka	1.06	3.37	0.71
Egypt	0.99	1.48	0.75	St. Vincent	1.91	2.03	0.74
El Salvador	1.71	1.41	1.26	Sudan	3.30	1.66	1.25
Eq. Guinea	3.89	3.97	5.25	Swaziland	0.94	0.71	1.21
Ethiopia	5.71	2.33	1.26	Tanzania	6.60	3.83	2.42
Fiji	0.74	0.11	1.55	Thailand	0.07	0.42	0.18
Gabon	0.49	0.55	0.62	Togo	4.78	3.57	2.30
Gambia	6.79	5.87	3.60	Tonga	5.28	1.81	6.60
Ghana	2.77	2.75	0.65	Turkey	0.09	0.23	0.05
Guatemala	0.60	0.40	0.49	Uganda	5.50	3.51	1.57
Guinea	4.22	3.79	1.54	Uruguay	0.06	0.07	0.12
Guinea-Bissau	10.60	6.30	5.66	Vanuatu	5.02	1.29	9.46
Honduras	2.59	2.69	1.11	Venezuela	0.01	0.01	0.03
India	0.10	0.44	0.07	Zambia	6.86	5.43	2.38
Indonesia	0.11	0.68	0.19				
Iran	0.12	0.01	0.04				
Jamaica	0.94	2.00	0.54				
Jordan	4.51	2.35	1.06				
Kenya	1.94	2.12	1.22				
Kiribati	12.24	0.68	12.73				
Laos	3.65	4.16	2.80				
Lesotho	5.66	3.79	4.45				

Notes: TA/GDP = technical assistance to GDP ratio.

Source: Author's calculations based on OECD DAC (2015).

Appendix A6: Classification of countries by income groups

Least Developed Countries (LDCs)	Other Low-Income Countries (LICs)
1. Angola	1. Algeria
2. Bangladesh	2. Argentina
3. Benin	3. Belize
4. Bhutan	4. Botswana
5. Burkina Faso	5. Cameroon
6. Burundi	6. Cape Verde
7. Central African Republic	7. Chile
8. Chad	8. China
9. Comoros	9. Colombia
10. Democratic Republic of Congo	10. Costa Rica
11. Congo Republic	11. Cote D'Ivoire
12. Equatorial Guinea	12. Dominica
13. Ethiopia	13. Dominican Republic
14. Gambia	14. Ecuador
15. Guinea	15. Egypt
16. Guinea-Bissau	16. El Salvador
17. Kenya	17. Fiji
18. Kiribati	18. Gabon
19. Laos	19. Ghana
20. Lesotho	20. Guatemala
21. Madagascar	21. Honduras
22. Malawi	22. India
23. Mali	23. Indonesia
24. Mauritania	24. Iran
25. Mozambique	25. Jamaica
26. Nepal	26. Jordan
27. Niger	27. Maldives
28. Rwanda	28. Mauritius
29. Sao Tome and Principe	29. Mexico
30. Senegal	30. Morocco
31. Sierra Leone	31. Nicaragua
32. Solomon Islands	32. Pakistan
33. Sudan	33. Panama
34. Tanzania	34. Papua New Guinea
35. Togo	35. Paraguay
36. Uganda	36. Peru
37. Vanuatu	37. Philippines
38. Zambia	38. Seychelles
	39. Sri Lanka
	40. St Vincent and the Grenadines
	41. Swaziland
	42. Thailand
	43. Tonga
	44. Turkey
	45. Uruguay
	46. Venezuela

Source: Author's based on the World Bank's income classification.