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Internet and the structure of public revenue: resource revenue versus non-resource revenue

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Abstract

This paper examines whether the Internet has led to a shift from reliance on resource revenue towards progressive reliance on non-resource revenue, which is ultimately a sustainable source of public revenue. The analysis has been carried out using a sample of 99 countries, including both developed and developing countries, over 1995–2015. Empirical results obtained from the use of the two-step system GMM approach suggest that the Internet induces a change in the structure of public revenue, in particular from resource revenue towards non-resource revenue. In addition, this effect is higher for less advanced countries than for more advanced economies. Thus, the Internet could be a powerful tool for governments to reduce their dependence on resource revenue, in particular in resource-rich countries.

Keywords: Internet, Resource revenue, Non-resource revenue

JEL Classification: H1, O3, Q33, Q38

1 Introduction

The diversification of public revenue, including from higher reliance on natural resource revenue towards progressive reliance on non-resource revenue, is an important challenge for policymakers, particularly in developing economies. This is because natural resource would sooner or later deplete and prompt countries whose public revenue is heavily dependent on resource revenues to be in a position of not being able to obtain the requisite financial resources to address development challenges. Furthermore, resource revenue is prone to the fluctuations of natural resource prices in the international market, over which governments cannot easily exert an influence. Authors such as Sachs and Warner (1999, 2001)[1] have argued that natural resources undermine rather than promote development prospects, including through the resource curse hypothesis whereby access to natural resources drives up the domestic price level, crowds out the tradeable manufacturing sector, and results in lower rates of productivity improvement and economic growth.

The issue concerning the diversification of public revenue from resource revenue to non-resource revenue is part of the more general issue of tax reforms advocated by many

[1] A different view has been proposed by Alexeev and Conrad (2009).

international financial institutions (such as the International Monetary Fund—IMF—and the World Bank) as well as regional development Banks. These tax reforms aim to progressively reduce countries' dependence on unsustainable sources of public revenue such as natural resource revenue and international trade tax revenue,[2] to the benefit of domestic non-resource tax revenue. While a wealth of studies has been devoted to the determinants[3] of public revenue mobilization, particularly in developing countries, little attention has been paid to the determinants, including macroeconomic factors, that govern tax reforms. Indeed, few authors such as Mahon (2004), Attila et al. (2009), Gnangnon (2017) and Gnangnon (2018) have performed analyses on the macroeconomic determinants of tax reforms or extent of tax reforms, but none of them have explored the relevance of the Internet to tax reforms (or to the extent of tax reforms).

The importance of the Internet for governments, including for public policymaking, has been highlighted in the emerging literature relating to the benefits for and impact of the Internet on public policy design. Internet provides countries with increasingly large sets of knowledge and information ("big data"), which can be easily diffused to large groups of people (see Paunov and Rollo 2016). Arthur (2007) has argued that by allowing for a wider access to ideas, the Internet may boost innovation, which arises from new combinations of existing pieces of knowledge. Margetts (2009) has underlined that a number of values normally associated with the Internet include innovation, trust, openness and equity. These views have also been shared by the Organization of Economic Cooperation and Development (OECD). The latter has noted that "…governments can leverage the Internet to co-ordinate and use public sector data to improve efficiency and service delivery to citizens" (see OECD 2016, p. 19). In addition, "an Internet whose openness allows for efficient collaboration of researchers across institutions and countries and for the sharing of data and knowledge is clearly a crucial instrument in policy makers' toolkit. Similarly, Internet openness could boost governments' efforts to support lifelong learning by offering workers a wider range of options through which to update their skills" (OECD 2016: p. 22). A number of studies have investigated the macroeconomic impact of the access to the Internet (henceforth referred to as "the Internet"). These include, for example, the impact of the Internet on economic growth (Noh and Yoo 2008; Salahuddin et al. 2016), international trade (e.g., Freund and Weinhold 2002, 2004; Clarke and Wallsten 2006; Vemuri and Siddiqi 2009; Lin 2015; Gnangnon and Iyer 2018), foreign direct investment (FDI) inflows (Choi 2003), inflation (Yi and Choi 2005), labour productivity (Najarzadeh et al. 2014), the size of the shadow economy (Elgin 2013) and corruption (Lio et al. 2011). To the best of our knowledge, Gnangnon and Brun (2018) have provided the only existing study (for the time being) that examines the relationship between the Internet and public revenue. By focusing on a sample comprising both developed and developing countries, the authors have examined the impact of the Internet gap (the gap between a country's Internet usage intensity and the world's

[2] Gnangnon (2017) has examined the impact of export upgrading on the extent of structural change in public revenue, notably from international trade tax revenue to non-international trade tax revenue. The current paper focuses on the structural change in public revenue, notably away from resource revenue to non-resource revenue.

[3] The bulk of these studies have used either total government revenue or total tax revenue (or the components of the latter) as the measure of government revenue (e.g., Khattry and Rao 2002; Ebrill et al. 1999; Agbeyegbe et al. 2006; Brun et al. 2007; Baunsgaard and Keen 2010; Brun et al. 2011; Clist and Morrissey 2011; Thomas and Treviño 2013; Crivelli and Gupta 2014; Brun et al. 2015; Morrissey 2015; Clist 2016; Morrissey et al. 2016; Yohou et al. 2016; von Haldenwangand Ivanyna 2017).

average Internet usage intensity) on non-resource tax revenue. Internet usage intensity is the share of Individuals using the Internet, in percentage of the total population.

The current paper complements two strands of the literature. The first strand concerns the macroeconomic determinants of tax reforms or the extent of tax reforms, and the second strand is relating to the literature on the macroeconomic impact of the Internet, in particular its impact on public revenue. Therefore, the paper investigates how the Internet (and not the Internet gap as defined by Gnangnon and Brun (2018) affects the dependence on resource revenue relatively to non-resource revenue, i.e., the extent of change in the structure of public revenue. To the best of our knowledge, this is the first study that addresses this issue.

We have hypothesized that the Internet would induce a shift in the public revenue structure form higher reliance on resource revenue to a higher on non-resource revenue, which reflects a greater extent of change from resource revenue to non-resource revenue. The empirical analysis has been carried out using an unbalanced panel dataset comprising 99 countries, including both developed and developing countries, over 7 sub-periods of non-overlapping 3-year average data covering the annual period 1995–2015. The extent of change from resource revenue to non-resource revenue is measured by the share of resource revenue to total public revenue. The empirical results have been obtained using the two-step system Generalized Methods of Moments (GMM) approach. They suggest that the Internet increases the extent of change in the structure of public revenue, from resource revenue to non-resource revenue. This finding leads to the conclusion that the Internet allows governments to move away, over the medium term, from the dependence of their public revenue on resource revenue towards non-resource revenue.

The rest of the analysis is structured as follows. Section 2 discusses the theoretical impact of the Internet on the share of resource revenue to total public revenue. Section 3 presents the model specification that allows examining empirically the impact of the Internet on the share of resource revenue to total public revenue. Section 4 discusses the empirical strategy. Section 5 interprets the estimations' results. Section 6 deepens the analysis, while Sect. 7 concludes.

2 Discussion on the theoretical impact of the Internet on change in the structure of public revenue

The Internet helps countries to have access to a larger set of information and knowledge. Hence, it could provide them with means to strengthen the capacity of relevant tax administrations in resource-rich countries to better monitor and easily collect resource revenue from firms exploiting natural resources. In addition, the access to information, thanks to the Internet, could help countries including developing ones take advantage of the experience of developed countries on the taxation of natural resource and on negotiations of "relatively" fair contracts for development and exploitation of natural resources by resource companies. This is particularly important for developing countries in which the tax administrations involved in natural resource taxation do not always have the requisite skills and knowledge needed to negotiate fair contracts with multinationals[4] that exploit these resources. Through these different channels, the Internet could help

[4] These multinational firms often have much more capacity and financial resources than governments, even in relatively advanced countries.

enhance the mobilization of resource revenue. At the same time, the Internet could also enhance the efficiency of tax administrations involved in the mobilization of non-resource tax revenue and generate higher non-resource revenue for concerned countries. Furthermore, the positive impact of the Internet on non-resource revenue could take place through international trade. Indeed, the greater access to the Internet contributes to promoting international trade (e.g., Freund and Weinhold 2002, 2004; Clarke and Wallsten 2006; Vemuri and Siddiqi 2009; Lin 2015; Gnangnon and Iyer 2018). In the meantime, international trade could generate higher non-resource revenue (Crivelli and Gupta 2014; Thomas and Treviño 2013; Brun et al. 2015).[5] Therefore, it could be expected that the Internet would likely generate higher non-resource revenue through international trade.

Notwithstanding this, the Internet could also exert a negative impact on resource revenue. Indeed, in the light of the relatively scarce technical and managerial skills needed to develop and exploit natural resources, it is usually foreign-owned firms (often in conjunction with state-owned companies, especially in the oil sector, or in joint ventures with domestically owned companies) that undertake resource exploitation and development activities (e.g., Boadway and Keen 2009). Hence, the international nature of the operations of resource companies allows them to easily develop tax avoidance strategies (e.g., Boadway and Keen 2009). Boyce and Ndikumana (2003) have noted that the resource sector is the main source of illicit financial flows and the size of the rents at stake, the asymmetry between highly capacitated foreign companies, combined with the weak governance and the lack of transparency in states, lead to non-negligible tax evasion and corruption in resource-rich countries. In this context, better access to the Internet would provide multinational resource companies with further opportunities of tax avoidance. These would result in lower levels of resource revenue than expected by governments of the host countries. Incidentally, Boadway and Keen (2009) have underlined that the tax avoidance challenges for the administration of natural resource tax could be easily overcome in the resource sector compared to other sectors. This is because the world prices of natural resources, in particular in the oil sector, are well established and could help governments monitor the transfer pricing arrangements within multinationals. However, in spite of the fact that natural resource prices are observable, tax avoidance opportunities still exist for multinational resource companies, including through the use of fiscal arrangements to shift taxable income from high to low tax jurisdictions. In addition, apart from the tax avoidance strategies developed to avoid or reduce tax payments, resource companies could also use a range of devices, including through transfer pricing, and profit shifting, in order to underste their profits in the host country once activity is under way (see Boadway and Keen 2009). A greater access to the Internet could also facilitate the development of these devices.

Summing up, on the one hand, while the Internet could exert a positive impact on resource revenue, it is likely that its negative impact on resource revenue—due to the enhancement of resource companies tax avoidance strategies—would outweigh the positive impact so that the net impact on resource revenue would be negative. At the same

[5] Note that Thomas and Treviño (2013), and Brun et al (2015) have reported a positive effect of trade openness on non-resource tax revenue, whereas Crivelli and Gupta (2014) have shown the existence of a mixed effect of non-resource trade openness on the mobilization of domestic non-resource tax revenue in resource-rich countries.

time, the Internet would likely influence positively non-resource revenue. We therefore expect that the Internet would lead to a higher impact on non-resource revenue relative to resource revenue, and hence a negative effect on the share of resource revenue in total public revenue. In the light of the potential losses of resource revenue that governments could incur, and given the fact that natural resource revenue is not a sustainable source of public revenue, we expect governments to engage in tax reforms, including by using the Internet, to reduce the dependence of its overall public revenue on resource revenue. Overall, we expect that the higher access to the Internet would lead to a higher extent of change in the structure of public revenue (i.e., a lower resource revenue share of total public revenue), notably through a progressive decline in resource revenue in favour of a rise in non-resource revenue.

3 Model specification

Before laying down the model specification that would help perform the empirical assessment of impact of the Internet on the change in the structure of public revenue, we first compare in Fig. 1 the evolution of resource revenue, in percentage of total public revenue, denoted "SHRESREV" and the evolution of the Internet usage intensity (denoted "INTERNET") over the full sample, using the non-overlapping 3-year sub-periods of the period 1995–2015.

This figure shows that the Internet usage intensity has constantly been on rise over the period, while the share of resource revenue in total public revenue has slightly declined between 1995–1997 and 1998–2000 and subsequently increased between 1998–2000 and 2004–2006. From 2004–2006 to 2010–2012, it has remained relatively stable and experienced again a decline between 2010–2012 and 2013–2015.

Figure 2 displays the evolution of "SHRESREV" and the "INTERNET" over the sub-sample of Resource Countries (henceforth denoted "ResCountries"). This sub-sample contains countries that have collected resource revenue at least once over the considered period. This figure presents a pattern similar to the one observed in Fig. 1. Overall, we note a tendency of a rise in the extent of tax reform from resource revenue to non-resource revenue during the last years of the period considered. From now onwards, we

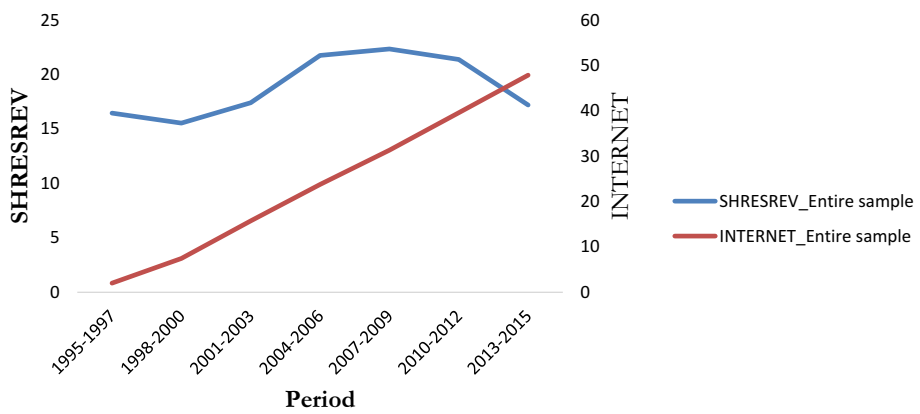

Fig. 1 Comparative evolution of "SHRESREV" and "INTERNET" over the full sample. *Note*: Non-overlapping 3-year average periods data have been used here. *Source*: Authors

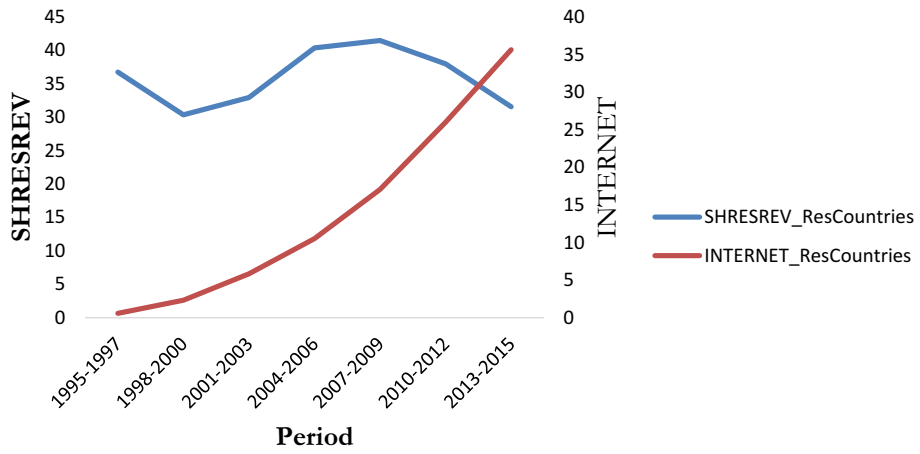

Fig. 2 Comparative evolution of "SHRESREV" and "INTERNET" over the sub-sample of Resource Countries. *Note*: Non-overlapping 3-year average periods data have been used here. *Source*: Authors

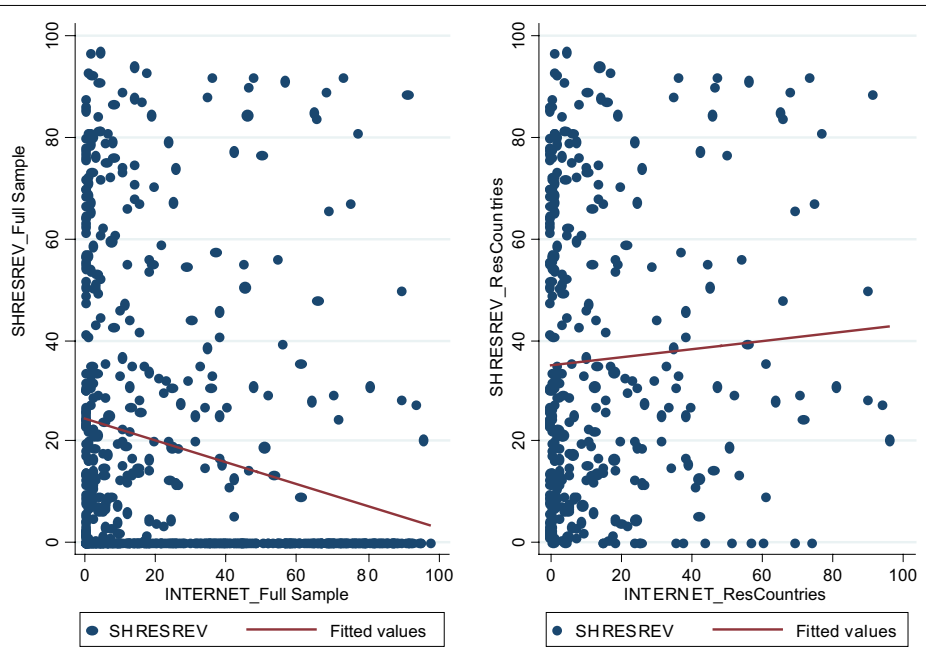

Fig. 3 Correlation pattern between "INTERNET" and "SHRESREV" over the full sample and sub-sample of "ResCountries". *Note*: Non-overlapping 3-year average periods data have been used here. *Source*: Authors

use the expression "change in the structure of public revenue" to refer to a shift in the public revenue structure, notably from higher reliance on resource revenue to a higher on non-resource revenue.

We provide in Fig. 3 the correlation pattern between the variables "INTERNET" and "SHRESREV" over the full sample (see the left-hand side of Fig. 3), as well as over the sub-sample "ResCountries" (see the right-hand side of Fig. 3). This figure shows a negative correlation between the Internet usage intensity and the share of resource revenue in total public revenue, and a slightly positive correlation pattern between these two variables for the sub-sample "ResCountries".

To examine empirically whether (and if so) how the Internet influences the extent of the change in the structure of public revenue, we draw from the conventional literature on the determinants of public revenue (e.g., Ghura 1998; Khattry and Rao 2002; Ebrill et al. 1999; Agbeyegbe et al. 2006; Brun et al. 2007, 2015; Baunsgaard and Keen 2010; Thomas and Treviño 2013; Crivelli and Gupta 2014; von Haldenwang and Ivanyna 2017) and particularly Gnangnon and Brun (2018), and Gnangnon (2018). We use a number of structural factors that have been identified as key determinants of countries' public revenue performance. These include the level of development, usually measured by countries' real per capita income; the degree of trade policy liberalization, the sectoral composition of domestic output, and the demographic characteristic measured for example by the population size. The inflation rate has also been considered as a key policy variable that influences public revenue.

Against this background, we postulate the following model (1):

$$\begin{aligned}\text{SHRESREV}_{it} = {} & \alpha_0 + \alpha_1 \text{SHRESREV}_{it-1} + \alpha_2 \textit{INTERNET}_{it} + \alpha_3 \text{Log(GDPC)}_{it} + \alpha_4 \text{TP}_{it} + \alpha_5 \text{INFL}_{it} \\ & + \alpha_6 \text{OILPR}_{it} + \alpha_7 \text{INST}_{it} + \alpha_8 \text{Log(POP)}_{it} + \mu_i + \alpha_9 \text{Trend} + \omega_{it}\end{aligned} \tag{1}$$

where i represents a given country; t denotes non-overlapping sub-periods of average 3 year. The model is estimated using a panel dataset comprising 99 countries, including both developed and developing countries, over 7 sub-periods of non-overlapping 3-year average data covering the annual period 1995–2015. These sub-periods include 1995–1997; 1998–2000; 2001–2003; 2004–2006; 2007–2009, 2010–2012 and 2013–2015. "Trend" represents a trend variable. α_0 to α_9 are parameters to be estimated. μ_i are country-specific effects. The disturbance term ω_{it} is assumed to be independently and identically distributed (i.i.d.; 0, σ_ε^2). The choice of countries and the time period are dictated by data availability.

The dependent variable "SHRESREV" stands for the share of resource revenue in total public revenue, which measures the extent of change in the structure of public revenue, from resource revenue to non-resource revenue. The one-period lag of this variable has been introduced in model (1) with a view to capturing the persistence over time (that is, the state dependence) in the share of resource revenue in total public revenue. This is in line with many studies (e.g., Agbeyegbe et al. 2006; Baunsgaard and Keen 2010; Thomas and Treviño 2013; Crivelli and Gupta 2014; Gnangnon and Brun 2018; Gnangnon 2018) on the determinants of public revenue performance that have estimated a dynamic model specification by considering the public revenue performance variable as a regressor.

"INTERNET" is the key variable of interest. Its impact on the extent of the change in the structure of public revenue has already been discussed in Sect. 2.

Brief discussion on the expect impact of control variables on the change in the structure of public revenue (resource revenue versus non-resource revenue)

"GDPC" is the real per capita income. It acts as a proxy for countries' overall development level. On the one hand, we expect that countries with higher development levels would be better equipped, including in terms of skills and institutional sophistication (for example, strong capacity of the tax administration to collect public revenue) to negotiate better contracts with resource-seeking multinationals (MNEs). Thus, advanced economies would be able to collect higher resource revenue than less advanced economies.

On the other hand, as resource revenue is not a sustainable source of public revenue, advanced economies would be willing to diversify their public revenue sources, including away from resource revenue to non-resource revenue. In particular, tax administrations in developed countries compared to less advanced economies have the requisite capacity and skills to diversify the sources of their resource revenue, from resource revenue towards non-resource revenue. Therefore, we expect countries with lower development levels to experience a lower extent of the change in the structure of public revenue from resource revenue to non-resource revenue, i.e., a decline in their ratio of resource revenue to non-resource revenue.

"TP" stands for the measure of domestic trade policy liberalization. Concerning the theoretical impact of domestic trade policy liberalization on resource revenue, the literature has demonstrated that trade policy liberalization can exert either a positive or a negative effect on public revenue, depending on several factors, including the structure of trade liberalization and the effect of the latter on each component of public revenue (e.g., Ebrill et al. 1999; Agbeyegbe et al. 2006). On the one hand, trade policy liberalization could attract resource-seeking FDI inflows that intend to exploit natural resources, with a view to exporting them to their home countries (these natural resources may be used as inputs in the production process of final goods in the home countries) or to export the final products to the international trade market. This may in turn result in higher resource revenue if the government of the host country does not exempt MNEs from paying revenue on the exploitation of these resources. At the same time, the host country's government can exempt resource-seeking MNEs (that intends to exploit and process the natural resource in the host country) from paying resource revenue if it intends to diversify its public revenue sources, notably through higher non-resource revenue mobilization, which is ultimately a more stable and sustainable public revenue source. Trade policy liberalization could particularly enhance the mobilization of higher non-resource revenue by, inter alia, promoting higher value added in the manufactured products—including the processing of natural resources that are sold either in the domestic market and/or exported abroad—and facilitating export diversification (see Gnangnon and Brun 2017). The literature on the determinants of public revenue has established that a higher value added in manufactured products (in % of total output) generates higher non-resource revenue (e.g., Thomas and Treviño 2013; Brun et al. 2015; Gnangnon and Brun 2017). Overall, it is difficult to anticipate the (average) impact of trade policy liberalization on the share of resource revenue in total public revenue, as this impact depends on the extent to which such liberalization influences non-resource revenue relative to resource revenue. Nevertheless, we postulate that the positive impact of trade policy liberalization on non-resource revenue would likely be higher than the one on resource revenue, so that trade policy liberalization would ultimately be associated with a higher extent of change in the structure of public revenue, i.e., a lower resource revenue share of total public revenue. It is worth recalling that a positive or a negative average impact across the full sample could reflect various impacts across countries in the sample. For example, during the last sub-period (2012–2015) of the analysis, the countries that experience the lowest level of trade policy liberalization include Iran, Zimbabwe, Chad, Equatorial Guinea, and Sudan.

"INF" stands for the inflation rate. This variable has been transformed because it contains negative and positive values. The transformation method used is the one suggested by Yeyati et al. (2007), which goes as follows: $Y = \text{sign}(X) * \log(1 + |X|)$ (2), where "X" denotes the variable to be transformed, $|X|$ refers to the absolute value of X, and "Y" is the outcome of the transformation. This method allows retaining information relating to zero observations and helps reduce the skewness of this variable. It is important to note that the alternative use of a Log-transformation of the "INF" variable based on the formula $Y = \log(1 + X/100)$ yields results that are similar to those obtained with the transformation method proposed by Yeyati et al. (2007). The latter results are not reported here to save space. They could be obtained upon request. According to Tanzi (1977), in an inflationary environment, lags in tax payments reduce, by the inflation rate, the real amount of tax paid (this effect is further enhanced if the tax system is not protected from inflation). Many studies (among those highlighted above) have reported a negative impact of inflation on public revenue. We expect that in an inflationary environment, both resource revenue and non-resource revenue would be adversely affected. The impact of inflation on the share of resource revenue in total public revenue depends on how it affects non-resource revenue relatively to resource revenue mobilization, and hence remains an empirical matter.

"OILPR" represents the oil prices (deflated by the US consumer price index). It stands for a proxy for natural resource prices. We expect a rise in natural resource prices to induce higher resource revenue, to discourage the mobilization of non-resource revenue, and therefore to induce a rise in the share of resource revenue in total public revenue. In this context, higher oil prices could lead governments, including those in developing countries to be inclined to rely on resource revenue as their major source of public revenue. However, as resource revenue is not a sustainable source of public revenue, governments that aim to reduce their dependence on natural resource revenue could engage in tax reforms, by moving away from resource revenue to non-resource revenue. In such a scenario, higher oil prices could lead in the medium to long term to a lower ratio of resource revenue to non-resource revenue, and hence to a decline in the ratio of resource revenue to total public revenue.

"INST" represents the indicator (a synthetic measure) of the institutional and governance quality. The importance of institutional and governance quality for public revenue mobilization has been emphasized in the empirical literature. For example, Ghura (1998) and Bird and Martinez-Vazquez (2008) have shown empirical evidence that institutional and governance quality improves the mobilization of public revenue. Therefore, we expect that countries with strong institutional and governance quality would be able to negotiate better contracts on the exploitation of natural resources, and hence collect higher resource revenue. However, as resource revenue is not a sustainable source of public revenue, such countries might also opt for diversification over the medium to long term, of their public revenue sources, including from resource revenue towards non-resource revenue. We can expect in this context that the better the institutional and governance quality, the lower the resource revenue (and the higher the non-resource revenue), and hence the lower the share of resource revenue in total public revenue. This argument is all the more relevant that countries with weak institutional and governance quality usually experience difficulties

in collecting non-resource revenue. Their alternative source of public revenue would therefore be the resource revenue. Overall, we expect better institutional and governance quality to be associated with a lower share of resource revenue in total public revenue. As it could be observed in Appendix 1, the synthetic measure of governance and institutional quality is computed by means of the factor analysis (notably the principal component analysis—PCA). In particular, we use the first principal components of six indicators of governance (for details, see Appendix 1) (e.g., Globerman and Shapiro 2002; Buchanan et al. 2012). Higher values of the "INST" indicator represent better governance and institutional quality. For example, during the last sub-period (2012–2015) of the analysis, the five countries with worst institutional and governance quality include Libya, Sudan, Yemen, Venezuela, and Equatorial Guinea.

The variable "POP", which represents the population size, has been introduced in the model to capture the impact of the population size on the extent of change in the structure of public revenue. On the one hand, Bahl (2003, p 13) has pointed out that in countries experiencing faster growing populations, tax systems may lag behind in the ability to capture new taxpayers. Accordingly, higher population could be negatively associated with non-resource revenue. On the other hand, the size of the population could influence resource revenue through its possible impact on FDI inflows. MNEs that are interested in exploiting natural resources with a view to adding value to these resources and serving the host country's domestic market (and eventually export abroad including to the regional markets) could be motivated to set up their plants in host countries that have an important market size, i.e., an important population size. The rise in the size of the population could result in higher FDI inflows and generate higher resource revenue for the host country's government, if the latter does not fully exempt these MNEs from the payment of resource revenue. However, the host country's government could decide to fully exempt MNEs from paying resource revenue (or request that the MNEs pay miniscule resource revenue) on the exploitation of the natural resources. Such a decision could be based on the expectation that the government would collect higher non-resource revenue from the high value-added products that the MNEs would sell in the domestic market, and possibly export. It is important to recall that exports of non-resource products with high value addition could also be an important source of non-resource revenue as they could generate higher jobs in the tradable sector as well as higher firms' profits. These jobs and the rise in firms' profits would generate higher non-resource revenue through, inter alia, higher corporate and personal income tax revenue. In the light of the foregoing, it would be difficult to anticipate the direction in which the population size would influence the extent of change in the structure of public revenue, i.e., the share of resource revenue in total public revenue. The empirical analysis would provide further guidance on this.

Appendix 1 provides the definition and source of the variables used in model (1), while Appendix 2 displays the list of countries used in the full sample as well as in the sub-sample "ResCountries". Descriptive statistics on these variables are provided in Appendix 3 (see Appendix 3 for these statistics).

4 Estimation strategy

We first estimate the static version of model (1) [i.e., model (1) without the one-period lag of the dependent variable as a regressor] by means of two standard econometric estimators: the pooled ordinary least squares (denoted "POLS-DK"), with standard errors being corrected using the Driscoll and Kraay (1998) technique to account for the presence of cross-sectional dependence and heteroscedasticity in the error term, and the within fixed effects (denoted FE-DK) where standard errors are corrected by means of the Driscoll and Kraay (1998) technique to account for the presence of cross-sectional dependence, serial correlation and heteroscedasticity in the error term. The results of these estimations are presented in Table 1. Second, we take into account the possible dynamic nature of model (1) and estimate model (1) as it stands (and its different variants, as we will see later) by means of the two-step system GMM estimator proposed by Arellano and Bond (1991) and Blundell and Bond (1998). The use of the two-step system GMM estimator involves the use of internal instruments of a system of equations, i.e., an equation in first differences where lagged levels of variables are used as instruments for the difference equation, and an equation in levels where lagged first differences of variables are used as instruments. Compared to the first-difference GMM estimator suggested by Arellano and Bond (1991), the two-step system GMM estimator performs better when cross-sectional variability dominates time variability and when there is a strong persistence in the time series under investigation (Blundell and Bond 1998). In addition, when the panel dataset is unbalanced, the difference GMM estimator has a weakness of magnifying gaps (see Roodman 2009). The two-step system GMM estimator has also the advantage of addressing the endogeneity problem that could stem from the presence of the one-period lag of the dependent variable (the so-called Nickell bias, see Nickell 1981) as a regressor, as well as other endogeneity issues that could arise from the estimation of model (1). Specifically, the variables "GDPC", "INFL", and "TP" could be considered as potentially endogenous, due to the eventual reverse causality from the dependent variable to

Table 1 Impact of the Internet usage intensity on the share (%) of resource revenue in total resource revenue. *Estimator*: POLS-DK and FE-DK

Variables	POLS-DK SHRESREV (1)	FE-DK SHRESREV (2)
INTERNET	− 0.144*** (0.0331)	− 0.0389*** (0.00567)
Log(GDPC)	15.78*** (0.142)	6.793** (2.600)
INFL	− 0.978 (0.984)	1.172*** (0.168)
TP	− 0.341*** (0.0872)	0.0363* (0.0185)
INST	− 11.44*** (0.291)	− 1.216*** (0.411)
OILPR	33.59*** (5.081)	10.67*** (3.025)
Log(POP)	− 1.744*** (0.363)	− 4.739 (3.751)
Constant	− 68.97*** (2.669)	27.93 (79.89)
Observations—countries	577—99	577—99
R-squared/within *R*-squared	0.491	0.1153

*p value < 0.1; **p value < 0.05; ***p value < 0.01. Robust standard errors are in parenthesis

Table 2 Impact of the Internet usage intensity on the share (%) of resource revenue in total resource revenue. *Estimator*: Two-step system GMM

Variables	SHRESREV (1)	SHRESREV (2)
$SHRESREV_{t-1}$	0.921*** (0.0204)	0.880*** (0.0465)
INTERNET	0.00838 (0.0132)	− 0.0558** (0.0274)
DUMRES*INTERNET		0.0864*** (0.0226)
DUMRES		− 13.33*** (2.745)
Log(GDPC)	2.972*** (0.649)	4.286*** (1.232)
INFL	− 2.924*** (0.242)	− 3.908*** (0.627)
TP	0.0763** (0.0296)	0.0363 (0.0460)
INST	− 3.488*** (0.366)	− 2.464*** (0.577)
OILPR	12.85*** (1.704)	14.06*** (2.746)
Log(POP)	− 1.705*** (0.406)	− 0.742 (1.010)
Trend	− 1.957*** (0.161)	− 2.036*** (0.303)
Constant	8.073 (8.597)	− 6.973 (20.36)
Observations—countries	493—99	493—99
Number of instruments	62	47
AR1 (*p* value)	0.0058	0.0047
AR2 (*p* value)	0.4799	0.3649
AR3 (*p* value)	0.3373	0.3118
Sargan (*p* value)	0.2141	0.1494

*p value < 0.1; **p value < 0.05; ***p value < 0.01. Robust standard errors are in parenthesis. The variables "Log(GDPC)", "INFL", and "TP" have been considered as endogenous. The other variables have been considered as exogenous. In particular, the variable "INST" has been considered as exogenous for two reasons: first, it changes little over time; second, the use of factor analysis severely mitigates the endogeneity concern that could stem from the reverse causality from the dependent variable

each of these variables. Therefore, in the regressions, we consider all these three variables as endogenous.

We check the validity of the two-step system GMM estimator through three tests: the Sargan test of over-identifying restrictions to confirm the validity of our internal instruments, the Arellano–Bond (AB) tests of first-and second-order serial correlation, respectively, denoted AR(1) and AR(2). (The null hypothesis of absence of second-order serial correlation in the disturbances should not be rejected, while the null hypothesis of absence of first-order serial correlation should be rejected.) Additionally, we present the results associated with the AR(3) test, where the null hypothesis of absence of third-order serial correlation in the disturbances should not be rejected. We also report the number of instruments used in the regressions, as if the number of instruments is higher than the number of countries, the above-mentioned diagnostics tests may lose power (see Roodman 2009).

Overall, the empirical analysis uses the two-step system GMM technique to estimate the dynamic model (1) and consider as endogenous the variables "Log(GDPC)", "INFL", and "TP". The other variables are considered as exogenous. The empirical analysis that uses the two-step system GMM approach therefore proceeds in several steps.

(i) First, we estimate model (1) over the full sample. The results of the estimation of this model specification are displayed in column (1) of Table 2.

(ii) Second, we estimate several variants of model (1) by means of the two-step system GMM approach. As observed above from Fig. 3 (see interpretation of the graph in Sect. 3), countries in the sub-sample of "ResCountries" exhibit a correlation pattern between the Internet usage intensity and resource revenue that is different from countries of the full sample. As a result, we would be tempted to suspect that in the empirical (causality analysis), there might be a different relationship between the Internet usage intensity and resource revenue in the sub-sample "ResCountries" compared to that of the full sample. Therefore, to check whether the effect of the Internet on the share of resource revenue in total public revenue is different in the full sample from the effect over the sub-sample "ResCountries", we create a dummy variable denoted "DUMRES", which takes the value "1" for countries that do not belong to the subgroup "ResCountries", and "0", otherwise, i.e., for countries in the sub-sample "ResCountries". This dummy variable is then interacted with the INTERNET variable, and both are introduced in model (1). Thus, the outcome associated with this interaction variable would reflect the effect of the Internet on resource revenue share of total public revenue for countries of the sample that are not included in the sub-sample of "ResCountries". As a result, the coefficient of the variable "INTERNET" would represent the genuine impact of the Internet on the share of resource revenue in total public revenue for the countries included in the sub-sample "ResCountries". The outcomes of the estimation of this model specification are provided in column (2) of Table 2. If the estimated coefficient of the INTERNET variable in column (2) of Table 2 is different from the estimated coefficient of the same variable in column (1) of Table 2, then the variant of model (1) with the "DUMRES" and its interaction with "INTERNET" would become our baseline model. In the event, the estimated coefficients in these two columns of Table 2 are similar, and then model (1) as it stands will remain the baseline model.

(iii) Third, we estimate another variant of model (1) where the dependent variable is the share of resource revenue (% GDP) (we add in this model specification the share of non-resource revenue, % GDP as a control variable). In this model specification, we also account for the effect of the Internet concerning countries in the sub-sample "ResCountries" versus other countries in the full sample. We additionally estimate another specification of model (1) where the dependent variable is the share of non-resource revenue (% GDP), while adding in this model specification the share of resource revenue, in % GDP, as a control variable. These two different model specifications are estimated using the two-step system GMM technique. The objective of these estimations is to examine how the Internet influences separately countries' performance in terms of resource revenue and non-resource revenue mobilization (measured, respectively, by their share in countries' GDP). The share of non-resource revenue, in % GDP, is measured by the difference between total public revenue and resource revenue, both expressed in % GDP. The results of these estimations are presented in Table 3.

Table 3 Impact of the Internet on the share of resource revenue (% GDP) and the share of non-resource revenue (% GDP) over full sample. *Estimator*: Two-step system GMM

Variables	RESREV (1)	NONRESREV (2)
One-period lag of the dependent variable	0.772*** (0.0300)	0.725*** (0.0334)
INTERNET	−0.00402*** (0.000833)	0.0177*** (0.00663)
DUMRES*INTERNET	0.00384*** (0.000636)	
DUMRES	−0.534*** (0.0921)	
NONRESREV	−0.0212*** (0.00430)	
RESREV		−0.0719*** (0.0147)
Log(GDPC)	0.180*** (0.0277)	−0.0638 (0.201)
INFL	−0.118*** (0.0161)	0.275* (0.147)
TP	0.00441*** (0.00144)	0.0204 (0.0134)
INST	−0.0686*** (0.0172)	0.670*** (0.170)
OILPR	0.392*** (0.0912)	−4.383*** (1.126)
Log(POP)	−0.0397** (0.0181)	0.0220 (0.149)
Trend	−0.0527*** (0.0118)	0.275*** (0.0928)
Constant	0.0500 (0.342)	3.673 (3.103)
Observations—countries	493—99	493—99
Number of Instruments	61	60
AR1 (*p* value)	0.0054	0.0000
AR2 (*p* value)	0.4599	0.3122
AR3 (*p* value)	0.8208	0.6319
Sargan (*p* value)	0.3500	0.2322

*p value < 0.1; **p value < 0.05; ***p value < 0.01. Robust Standard Errors are in parenthesis. The variables "Log(GDPC)", "INFL", and "TP" have been considered as endogenous. Additionally, the variable "NONRESREV" has been considered as endogenous in column (1), and the variable "RESREV" has been considered as endogenous in column (2). In column (1), as the variable "RESREV" contains many zeros and exhibit a high skewness, it has been transformed using the transformation method proposed by Yeyati et al. (2007). The other variables have been considered as exogenous. In particular, the variable "INST" has been considered as exogenous for two reasons: first, it changes little over time; second the use of factor analysis severely mitigates the endogeneity concern that could stem from the reverse causality from the dependent variable

5 Interpretation of empirical results

The results of the estimations of the static version of model (1) using the POLS-DK and the FE-DK estimators are reported in Table 1. Results across the two columns of this table show that the Internet exerts a negative and statistically significant impact (at the 1% level) on the share of resource revenue in total public revenue, i.e., it helps shift the structure of public revenue towards an increasing reliance on non-resource revenue at the expense of resource revenue. Focusing specifically on the results reported in column (2) of Table 1 (based on the FE-DK), we obtain that the positive drivers of resource revenue include higher real per capita income, trade policy liberalization (although it is statistically significant only at the 10% level), higher oil prices, and higher inflation rate. The population size does not influence significantly the ratio of resource revenue to total public revenue.

Let us now consider the results of Tables 2 and 3. We note across the columns of these tables that the coefficient associated with the one-period lag of the dependent variable is positive and statistically significant at the 1% level, thereby confirming that the state-dependence path the revenue share variables, i.e., their persistence over time. In addition, the p values associated with the AR(1) test are always lower than 0.01—they should indeed at least be lower than 10%; the p values relating to the AR(2) and AR(3) tests are

all higher than 0.10; and the Sargan statistic is always associated with a p value higher than 10%. Incidentally, across all columns (as suggested by Roodman 2009), the number of instruments used in the regressions is consistently lower than the number of countries. Taken together, all these results confirm the validity of the two-system GMM system approach to carry out the empirical analysis.

Turning specifically to results in Table 2, we obtain from column (1) of this table that the coefficient associated with the variable INTERNET is not statistically significant at the 10% level, whereas in column (2) which includes the variable "DUMRES", we obtain a negative and significant effect (at the 1% level) of the Internet usage intensity on the share of resource revenue in total public revenue. This clearly suggests that the Internet facilitates the shift from reliance on resource revenue to an increasing dependence on non-resource revenue in the overall public revenue. In particular, we note that a 1-percentage point increase in the Internet usage intensity is associated with a 0.056-percentage point decline in the share of resource revenue in total public revenue for countries contained in the sub-sample of "ResCountries". In the light of these findings, our baseline model would henceforth be the one that contains the dummy variable "DUMRES" along with its interaction with the "INTERNET" variable. Moving on to results related to control variables in column (2) of Table 2, we observe that trade policy liberalization and the population size exert no significant effect on the share of resource revenue in total public revenue. Higher oil prices, lower inflation rate and lower institutional and governance quality induce a rise in the share of resource revenue in total public revenue. As expected, countries with higher real per capita income (higher development level) tend to mobilize higher share of resource revenue in total public revenue compared to less developed countries: this is exemplified by the positive and statistically significant coefficient of the variable capturing the real per capita income. The coefficient associated with the "Trend" variable is negative and statistically significant, therefore suggesting a decline in the share of resource revenue in total public revenue over time.

Let us now examine the estimates reported in Table 3. Results indicate that the Internet exerts a negative and significant effect on countries' resource revenue performance (i.e., the share of resource revenue in GDP) [see column (1) of the table] and a positive and significant effect on countries' non-resource revenue performance (i.e., the share of non-resource revenue in GDP) [see column (2) of the table]. Hence, for countries contained in the sub-sample of "ResCountries", a 1-percentage point increase in the Internet usage intensity is associated with a 0.402-percentage decline in the ratio of resource revenue to GDP. Similarly, over the full sample, a 1-percentage point increase in the Internet usage intensity leads to a 0.018-percentage point increase in the share of non-resource revenue (% GDP). Incidentally, as per results in column (1), we note that a rise in the non-resource revenue share of GDP influences negatively and significantly the resource revenue share of GDP: a 1-percentage point increase in the non-resource revenue share induces a 2.12-percentage decline in the ratio of resource revenue to GDP. Likewise, a rise in the resource revenue share exerts a negative and significant impact on the non-resource revenue share of GDP: a 1-percentage point increase in the resource revenue share leads to a 0.072-percentage point fall in the share of non-resource revenue (% GDP). Results related to other control variables in column (1) suggest that the positive drivers of resource revenue share of GDP include higher real per capita income,

lower inflation rate, trade policy liberalization, lower quality of institutions and governance, higher oil prices, and lower population size. The resource revenue share of GDP exhibits a declining trend over time. This is exemplified by the negative and statistically significant coefficient of the Trend variable in column (1) of the Table. In column (2), we obtain rather that the non-resource revenue share of GDP exhibits a rising trend over time. Additionally, at the 5% level, only better institutional and governance quality and lower oil prices influence positively and significantly the non-resource revenue share of GDP. The other control variables are not statistically significantly related to this revenue share at the 5% level.

Overall, these findings suggest that by negatively and significantly influencing the share of resource revenue in total public revenue, the Internet induces a shift in the total public revenue structure from resource revenue towards non-resource revenue in countries that collect resource revenue. These results are confirmed by the negative effect of the Internet on countries' resource revenue performance (i.e., their resource revenue share of GDP) and the positive impact of the Internet on countries' non-resource revenue performance (i.e., their non-resource revenue share of GDP).

6 Further analysis

In this section, we investigate whether the effect of the Internet on the share of resource revenue in total public revenue obtained over the full sample varies across several subsamples (based on countries' development levels) of the full sample. Indeed, we postulate that countries with higher levels of development would likely have greater capacity to manage their natural resources, including by negotiating better contracts with firms that intend to exploit these resources. At the same time, they could also use the advantages associated with their high level of access to the Internet (and to the new technologies for information and communication) to collect higher resource revenue, even though these firms could also use their access to the Internet to escape the payment of these resources. Thus, even if both advanced countries and less advanced ones have advantage of changing greatly their public revenue structure toward a higher dependence on non-resource revenue, we do expect that the Internet would exert a higher reducing effect on the share of resource revenue in total public revenue in advanced economies than in less advanced countries. The sub-samples considered in the analysis include "Low-Income countries" (denoted "LICs"), "Lower Middle-Income countries" (denoted "LMICs"), "Upper Middle-Income countries" (denoted "UMICs"), and "High-Income countries" (denoted "HICs"), as per the World Bank's classification of countries. The lists of countries contained in the sub-samples are presented in Table 8 in Appendix 2. To perform the analysis, we create a dummy variable for each of these sub-samples (this dummy takes the value 1 when a country belongs to the concerned sub-sample, and 0, otherwise), which we interact with the INTERNET variable. Each dummy variable and its interaction with the INTERNET variable are included once in model (1), along with the "DUMRES" variable and its interaction with the variable "INTERNET". Results of the estimations are provided in Table 4. Once again, the results of the diagnostic tests that help check the validity of the two-step system GMM approach are reported at the bottom of this table and show that this estimator is well appropriate to perform the different estimations whose results are reported in the table. Turning now to the estimates

Table 4 Differentiated impact of the Internet usage intensity on the share (%) of resource revenue in total resource revenue across various sub-samples. *Estimator*: Two-Step System GMM

Variables	SHRESREV (1)	SHRESREV (2)	SHRESREV (3)	SHRESREV (4)
$SHRESREV_{t-1}$	0.842*** (0.0391)	0.839*** (0.0389)	0.813*** (0.0154)	0.856*** (0.0333)
INTERNET	−0.0810*** (0.0253)	−0.0631*** (0.0217)	−0.0340*** (0.00990)	−0.0978*** (0.0216)
LIC*INTERNET	−0.344 (0.229)			
LMIC*INTERNET		−0.142** (0.0633)		
UMIC*INTERNET			−0.0248* (0.0148)	
HIC*INTERNET				0.0951*** (0.0249)
LIC	8.098** (3.949)			
LMIC		−3.555 (4.455)		
UMIC			5.718*** (0.923)	
HIC				−5.642 (3.502)
DUMRES*INTERNET	0.0906*** (0.0223)	0.0781*** (0.0195)	0.0683*** (0.00869)	0.0336* (0.0173)
DUMRES	−17.85*** (2.585)	−18.45*** (2.355)	−15.59*** (1.130)	−12.03*** (2.120)
Log(GDPC)	6.895*** (1.390)	3.960*** (1.054)	4.571*** (0.601)	4.372*** (1.205)
TP	0.0260 (0.0456)	0.0853** (0.0430)	0.0674*** (0.0230)	0.111*** (0.0318)
INFL	−3.245*** (0.595)	−2.515*** (0.561)	−2.150*** (0.137)	−3.329*** (0.360)
OILPR	13.61*** (2.603)	10.43*** (2.757)	12.69*** (1.344)	12.94*** (1.882)
INST	−2.902*** (0.559)	−2.193*** (0.433)	−2.557*** (0.234)	−2.399*** (0.476)
Log(POP)	−0.215 (1.032)	−1.566 (1.077)	−1.278** (0.550)	−1.942** (0.808)
Trend	−1.810*** (0.292)	−1.547*** (0.296)	−1.970*** (0.111)	−1.977*** (0.212)
Constant	−36.94* (20.80)	6.960 (21.26)	−5.386 (10.52)	7.540 (17.55)
Observations—countries	493—99	493—99	493—99	493—99
Number of instruments	52	52	73	60
AR1 (*p* value)	0.0050	0.0050	0.0046	0.0044
AR2 (*p* value)	0.4067	0.5065	0.5670	0.4495
AR3 (*p* value)	0.4424	0.4451	0.4540	0.3822
Sargan (*p* value)	0.1538	0.1742	0.2749	0.2806

*p value < 0.1; **p value < 0.05; ***p value < 0.01. Robust standard errors are in parenthesis. The variables "Log(GDPC)", "INFL", and "TP" have been considered as endogenous. The other variables have been considered as exogenous. In particular, the variable "INST" has been considered as exogenous for two reasons: first, it changes little over time; second, the use of factor analysis severely mitigates the endogeneity concern that could stem from the reverse causality from the dependent variable

provided in columns (1) to (4) of this table, we can calculate the net impact of the Internet on the share of resource revenue in total public revenue for each of the sub-samples. At the 5% level, the magnitude of this net impact in LICs, LMICs, UMICs, and HICs amounts, respectively, to -0.0810; -0.205 ($=-0.0631-0.142$); -0.0340; and -0.0027 ($=-0.0978+0.0951$). These results show that the net impact of the Internet on the share of resource revenue in total public revenue is always negative for all the sub-samples. In particular, a 1-percentage point increase in the Internet usage intensity is associated with a decline in the share of resource revenue in total public revenue, respectively, by 0.08-percentage point in LICs, 0.205 percentage point in LMICs, 0.034 percentage point in UMICs, and 0.0027 percentage point in HICs. As expected, HICs appear to be the group of countries that experience the lowest negative impact of the Internet on the share of resource revenue in total public revenue. At the same time, the magnitude of the

Table 5 Does the impact of the Internet usage intensity on the share (%) of resource revenue in total resource revenue depend on countries' level of development?

Variables	SHRESREV (1)
$SHRESREV_{t-1}$	0.835*** (0.0173)
INTERNET	− 0.285*** (0.0353)
[Log(GDPC)]*[INTERNET]	0.0202*** (0.00337)
Log(GDPC)	4.350*** (0.714)
DUMRES*INTERNET	0.0878*** (0.00814)
DUMRES	− 14.22*** (1.206)
TP	0.0623*** (0.0174)
INFL	− 2.207*** (0.178)
OILPR	16.70*** (1.211)
Log(POP)	− 0.448 (0.427)
INST	− 2.646*** (0.351)
Trend	− 1.937*** (0.131)
Constant	− 16.23 (10.87)
Observations—countries	493—99
Number of instruments	77
AR1 (*p* value)	0.0053
AR2 (*p* value)	0.6113
AR3 (*p* value)	0.5193
Sargan (*p* value)	0.1859

*p value < 0.1; **p value < 0.05; ***p value < 0.01. Robust standard errors are in parenthesis. The variables "Log(GDPC)", "INFL", and "TP" have been considered as endogenous. The other variables have been considered as exogenous. In particular, the variable "INST" has been considered as exogenous for two reasons: first, it changes little over time; second, the use of factor analysis severely mitigates the endogeneity concern that could stem from the reverse causality from the dependent variable

reducing impact of the Internet on the share of resource revenue in total public revenue is higher in LMICs than in LICs, which in turn outstrips that of UMICs. It is important to recall here that these net impacts across sub-samples represent the "average" impact over each sub-sample and therefore may hide different impacts across countries within each sub-sample. Results concerning control variables are broadly in line with those in column (2) of Table 2.

We go deeper into the analysis and avoid the use of "subjective" sub-samples by examining whether and if so how the impact of the Internet on the share of resource revenue in total public revenue varies across countries in the full sample. To address this question, we estimate a variant of model (1), which includes a variable capturing the interaction between the variables INTERNET and Log(GDPC). As highlighted above, we expect that countries with a higher development level would experience a lower negative impact of the Internet on the share of resource revenue in total public revenue, compared to countries with lower development levels.

Results of the estimation of this variant of the model (1) are displayed in Table 5. The results of the diagnostic tests that help assess the validity of the two-step system GMM approach (see the bottom of Table 5) confirm the appropriateness of this estimator to conduct the empirical analysis. Let us now consider the results reported in Table 5. To analyse how the impact of the Internet on the share of resource revenue in total public revenue varies for different levels of development, we particularly rely on the coefficient

of the variable INTERNET as well as on the interaction term associated with the interaction variable "[INTERNET]*[Log(GDPC)]". Results indicate that the coefficient associated with the variable INTERNET is negative and statistically significant at the 1% level, whereas at the same time, the interaction term is positive and statistically significant at the 1% level. This means that the total effect of the Internet on the share of resource revenue in total public revenue decreases as countries experience higher real per capita income; but above a certain level of real per capita income—given by US$ 1,340,979.5 [=exponential (0.285/0.0202)]—this impact becomes positive. In the panel dataset considered in the analysis, the 3-year average values of the real per capita income range between US$ 157.57 and US$ 106,579.2 (see Appendix 3). As the threshold (US$ 1,340,979.5) of the real per capita income above which the impact of the Internet on resource revenue changes sign is not contained in this interval (it is far higher than the maximum value of the real per capita income), we do conclude that, on average, whatever countries' development level, the Internet always exerts a negative and significant impact on the share of resource revenue in total public revenue. Additionally, the higher the development level, the higher is the magnitude of the negative impact of the Internet on the share of resource revenue in total public revenue. Nevertheless, these results might not provide a clear picture on the extent to which the impact of the Internet on the share of resource revenue in total public revenue varies across countries in the full sample. This is because this impact could hold different magnitudes, signs and statistical significances for various countries' development levels. To have a better picture on this impact, we present in Fig. 4, at the 95 per cent confidence intervals, the evolution of the

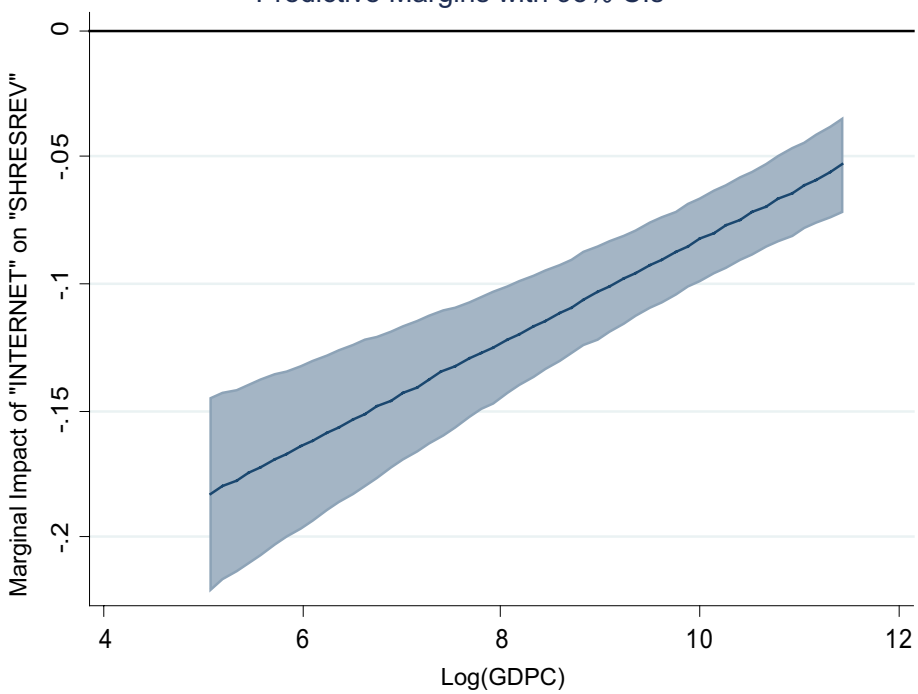

Fig. 4 Marginal impact of "INTERNET" on "SHRESREV", for varying countries' levels of development. *Source*: Authors

marginal effect of INTERNET on SHRESREV for different countries' levels of economic development (proxied by real per capita income). It is worth noting that the statistically significant impacts at the 95 per cent confidence intervals are those encompassing only the upper and lower bounds of the confidence interval that are either above or below the zero line.

The figure indicates that the marginal impact of INTERNET on RESREV is always statistically significant. The magnitude of this negative effect diminishes as countries experience higher real per capita income, i.e., as they develop. This pattern clearly reveals that countries that are less developed experience a higher negative impact of the Internet on the share of resource revenue in total public revenue than relatively more developed countries, in particular advanced economies. In other words, the Internet induces a higher extent of change in the structure of total public revenue—from lower reliance on resource revenue in favour of higher reliance on non-resource revenue—in less advanced countries than in more advanced economies that draw public revenue from natural resources. This means that the Internet could greatly facilitate a 'structural change' in the overall public revenue structure, particularly in poor countries that extract public revenue from their natural resources.

7 Conclusion

This paper analyses the impact of the Internet on resource revenue in a sample of 99 countries, including both developed and developing countries, over the period 1995–2015 (non-overlapping periods of 3-years have been used). Based on the two-step system GMM approach, the empirical analysis suggests that over the full sample, the Internet exerts a negative and significant effect on the share of resource revenue in total public revenue. In other words, the Internet induces a positive extent of the change in the structure of the overall public revenue, from resource revenue towards non-resource revenue, which is ultimately the most sustainable source of public revenue. These results are confirmed by a negative effect of the Internet on countries' performance in terms of resource revenue, measured by the resource revenue share of GDP, and a positive effect of the Internet on countries' performance in terms of non-resource revenue, measured by the non-resource revenue share of GDP. These results are also valid, although with different magnitudes, when we consider the impact of the Internet on the share of resource revenue in total public revenue across various sub-samples. More generally, the analysis shows that the impact of the Internet on the share of resource revenue in total public revenue depends on countries' levels of development, proxied by their real per capita income. Specifically, the higher the countries' development level, the lower is the magnitude of the extent of change in the structure of the total public revenue, from resource revenue to non-resource revenue. This suggests that countries that are less developed experience a higher extent of change in the structure of their overall public revenue (resource revenue vs non-resource revenue) than advanced economies. Even though more advanced countries have advantage of changing greatly their public revenue structure toward a higher dependence on non-resource revenue, they still have a higher capacity than less developed countries (and even more so poor countries) to negotiate better contracts with resource-seeking firms. They could additionally use the advantages provided by their high level of access to the Internet (and to the new

technologies for information and communication), to collect higher resource revenue despite the fact that MNEs could also use their access to the Internet to escape the payment of resource revenue. Overall, the Internet could be a powerful tool for governments, notably developing countries, and particularly poor countries, to promote the change in the structure of their public revenue, notably from lower reliance on resource revenue at the benefit of a higher dependence on non-resource revenue.

Authors' contributions
The two authors contribute to the drafting of all sections of the paper.

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Appendices

Appendix 1

See Table 6.

Table 6 Variables, definitions, and sources

Variable	Definition	Source
TOTREV	This the ratio of total public revenue (% GDP)	ICTD Public revenue Dataset. See online: https://www.wider.unu.edu/project/government-revenue-dataset
RESREV	This is the total resource revenue, in % GDP. It is the total natural resource revenues, including natural resource revenues reported as "tax revenue" or "non-tax revenue". Natural resources are here defined as natural resources that include a significant component of economic rent, primarily from oil and mining activities	ICTD Public revenue Dataset. See online: https://www.wider.unu.edu/project/government-revenue-dataset
NONRESREV	This is the measure of non-resource revenue, in % GDP. It is the difference between total public revenue and resource revenue, both expressed, in % GDP	Authors' calculation. Data on both total public revenue and resource revenue are extracted from the ICTD: ICTD Public revenue Dataset. See online: https://www.wider.unu.edu/project/government-revenue-dataset
SHRESREV	This is the share (%) of resource revenue to total public revenue. SHRESREV = RESREV*100/TOTREV	Authors' calculation. Data on both total public revenue and resource revenue are extracted from the ICTD: ICTD Public revenue Dataset. See online: https://www.wider.unu.edu/project/government-revenue-dataset
INTERNET	This variable measures the share of Individuals using the Internet, in percentage of the total population	World Development Indicators (of the World Bank) (WDI)
TP	Trade policy of the domestic economy = trade freedom score; this is a component of the Economic Freedom Index. It is composite measure of the absence of tariff and non-tariff barriers that affect imports and exports of goods and services. Its computation is based on two components: trade-weighted average tariff rage and non-tariff barriers (NTBs), the extent of latter having been determined on the basis of quantitative and qualitative available information. NTBs include quantity restrictions, price restrictions, regulatory restrictions, investment restrictions, customs restrictions, and direct government interventions. This score is graded on a scale of 0–100, with a rise indicating lower trade barriers, i.e., higher trade liberalization, while a decrease in this index reflects rising trade protectionism	Heritage Foundation (see Miller et al. 2017)
GDPC	GDP per capita (constant 2010 US$)	WDI
INFL	Inflation rate (%)	WDI
POP	Total population	WDI
OILPR	This is the oil prices, in US dollars, deflated by the Index of United States' Consumer Price Index for All Urban Consumers	Data on both the oil prices and the US consumer price index are extracted from the Federal Reserve Economic Data (see online at: https://fred.stlouisfed.org)

Table 6 (continued)

Variable	Definition	Source
INST	This is the variable capturing institutional quality in a given country. It has been computed by extracting the first principal component (based on factor analysis) of the following six indicators of governance. These indicators are, respectively, denoted "PolStab", "RegQual", "Ruleslaw", "GovEff", "VoiceAcc", and "Cor" "PolStab" is the measure of political stability and absence of violence/terrorism. "RegQual" stands for Regulatory Quality index. "Ruleslaw" represents the Rules of Law index. "GovEff" is the Government Effectiveness index. "VoiceAcc" is the index of Voice and Accountability: "Cor" is the index of corruption It is worth noting that higher values of the index "INST" are associated with better governance and institutional quality, while lower values reflect worse governance and institutional quality	Data on the components of "INST" variables have been extracted from World Bank Governance Indicators developed by Kaufmann, Kraay, and Mastruzzi (2010) and updated in 2018

Appendix 2

See Table 7, 8.

Table 7 List of the 99 countries contained in the entire sample

Entire sample				
Algeria	Dominica	Israel	Namibia	Slovenia
Angola	Egypt, Arab Rep.	Italy	Netherlands	St. Vincent and the Grenadines
Austria	Equatorial Guinea	Jamaica	New Zealand	Sudan
Azerbaijan	Estonia	Japan	Niger	Suriname
Bahrain	Ethiopia	Kazakhstan	Nigeria	Sweden
Belgium	Fiji	Korea, Rep.	Norway	Switzerland
Bolivia	Finland	Kuwait	Pakistan	Thailand
Botswana	France	Lao PDR	Papua New Guinea	Timor-Leste
Brunei Darussalam	Gabon	Latvia	Paraguay	Togo
Bulgaria	Germany	Liberia	Portugal	Trinidad and Tobago
Burkina Faso	Ghana	Libya	Qatar	Tunisia
Cameroon	Greece	Lithuania	Romania	Uganda
Canada	Guinea	Luxembourg	Russian Federation	United States
Chad	Haiti	Malaysia	Rwanda	Vanuatu
Chile	Hong Kong SAR, China	Malta	Sao Tome and Principe	Venezuela, RB
Colombia	Iceland	Mauritania	Saudi Arabia	Vietnam
Congo, Rep.	India	Mauritius	Senegal	Yemen, Rep.
Cote d'Ivoire	Indonesia	Mexico	Serbia	Zambia
Croatia	Iran, Islamic Rep.	Moldova	Sierra Leone	Zimbabwe
Cyprus	Ireland	Mongolia	Slovak Republic	

Table 8 List of the countries contained in the different sub-samples used in the analysis

LICs	LMICs	UMICs	HICs	
Burkina Faso	Bolivia	Algeria	Austria	New Zealand
Chad	Cameroon	Angola	Bahrain	Norway
Ethiopia	Congo, Rep.	Azerbaijan	Belgium	Portugal
Guinea	Cote d'Ivoire	Botswana	Brunei Darussalam	Qatar
Haiti	Egypt, Arab Rep.	Bulgaria	Canada	Saudi Arabia
Liberia	Ghana	Colombia	Chile	Slovak Republic
Niger	India	Dominica	Croatia	Slovenia
Rwanda	Indonesia	Equatorial Guinea	Cyprus	Sweden
Senegal	Lao PDR	Fiji	Estonia	Switzerland
Sierra Leone	Mauritania	Gabon	Finland	Trinidad and Tobago
Togo	Moldova	Iran, Islamic Rep.	France	United States
Uganda	Mongolia	Jamaica	Germany	
Zimbabwe	Nigeria	Kazakhstan	Greece	
	Pakistan	Libya	Hong Kong SAR, China	
	Papua New Guinea	Malaysia	Iceland	
	Sao Tome and Principe	Mauritius	Ireland	
	Sudan	Mexico	Israel	
	Timor-Leste	Namibia	Italy	
	Tunisia	Paraguay	Japan	
	Vanuatu	Romania	Korea, Rep.	
	Vietnam	Russian Federation	Kuwait	
	Yemen, Rep.	Serbia	Latvia	
	Zambia	St. Vincent and the Grenadines	Lithuania	
		Suriname	Luxembourg	
		Thailand	Malta	
		Venezuela, RB	Netherlands	

Appendix 3

See Table 9.

Table 9 Descriptive statistics on variables

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
SHRESREV	619	18.981	27.474	0.000	96.554
INTERNET	684	24.183	27.889	0.000	97.636
TOTREV	673	25.326	10.340	5.538	78.447
RESREV	621	5.929	10.888	0.000	63.204
NONRESREV	619	20.254	9.625	1.742	44.617
GDPC	688	15278.850	19927.280	157.565	106579.200
TP	649	69.050	15.147	9.067	95.000
INFL	684	48.819	937.667	−6.934	24411.030
INST	689	0.135	2.368	−4.826	4.800
OILPR	693	0.262	0.126	0.117	0.449
POP	693	3.74e+07	1.22e+08	69841.33	1.30e+09

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