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RESEARCH ARTICLE

# Constraints on the executive and tax revenues in the long run

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**Abstract**

We argue that tax revenues and political institutions placing constraints on the executive power may reinforce each other over time and so co-evolve in the long run. This may also bring a shift in the composition of revenues, from taxes levied on a narrow base to broadly levied taxes. To test these hypotheses, we use historical cross-country data covering 31 countries for 1800–2012 and panel time series methods allowing for different forms of country-specific heterogeneity and cross-section dependence. The results offer three main findings. First, executive constraints, whether they are judicial or legislative, and tax revenues are cointegrated. While in the short run they can drift apart, this will be temporary because there is a long-run relationship between the two. Second, evidence of cointegration is strongest for revenues from direct taxes, suggesting that the existence and nature of a long-run relationship may be mainly related to the emergence of broad-based taxation. Third, long-run causality runs mostly from executive constraints to taxation. This is most evident for income taxes. Our findings link Sustainable Development Goals 16 and 17, implying that the goal of promoting inclusive and accountable institutions may work in synergy with that of generating internal resources to finance development goals.

**Key words:** Constraints on the executive; fiscal capacity; institutions; SDG17; tax revenues

**JEL classification:** O4; P5; H61; H83; P48; N46; N47

## 1. Introduction

Modern states are much more complex organisations and perform a much broader range of functions than states did only a century ago, and they have an important role in economic development. Recent research argues that the most developed economies are those where effective states can exercise a crucial productive role, such as providing public goods and services, effectively administering justice and resolving coordination failures.[1] Acquiring *fiscal capacity* is a fundamental condition for effective statehood. This required transitioning from a state relying on resources derived from the monarch's domain to a state where its resources come from the power to tax, ultimately developing a sophisticated tax administration, capable of raising revenues from a broad tax base.

Research on how tax systems arise and develop has extensively studied this process in European countries (e.g. Bonney, 1999; Tilly, 1992). It is not clear, however, whether findings from advanced economies can be extended to and illustrate how developing countries learn to tax (e.g. Yun-Casalilla and O'Brien, 2011), as their states are much less effective and often taxation yields

[1]For reviews of this literature, see Acemoglu and Robinson (2019), Bardhan (2016) and Besley and Persson (2011).

only a fraction of the revenues compared to rich countries.[2] Understanding such mechanisms would provide states in less developed economies with much-needed resources to fund public goods and services, and it is policy relevant, because Sustainable Development Goal 17 highlights the importance of generating internal resources to finance development goals.[3]

This paper focuses on the dynamic relationship between political institutions placing limits on the executive power and taxation. It is increasingly recognised that constraints on the executive power can be an important condition to explain reforms or the inertia of tax systems (e.g. Besley and Persson, 2011).[4] However, it is not well documented how these constraints affect tax revenues and whether they affect each other over time. This paper contributes to a fairly thin empirical literature in this area, providing new evidence on the relationship between political institutions limiting the executive power and the amount and composition of government revenues. We argue that tax revenues and executive constraints may reinforce each other over time and so co-evolve in the long run. This may also bring a shift in the composition of revenues, from taxes levied on a narrow base to broadly levied taxes. To test the above hypotheses, we use panel time series methods and recent historical cross-country data from the V-Dem project (Coppedge *et al*., 2020) and Andersson and Brambor (2019), covering 31 countries over the 1800–2012 period. Allowing for different forms of country-specific heterogeneity and cross-section correlation, the paper offers three main findings. First, we find that executive constraints and tax revenues are cointegrated: there is a long-run relationship between the two. This implies that, while in the short-run executive constraints or tax revenues can drift apart, one variable drives the other. Second, the result is most evident for direct taxes, often significant for indirect tax revenues, and absent for trade taxes. Third, we find evidence that long-run causality runs mostly from executive constraints to taxation. These findings highlight the importance of executive constraints as a structural condition for fiscal development, as well as the emergence of broad-based taxation as a key source to finance the state and support political institutions keeping the government accountable for its actions.

The paper proceeds as follows. In section 2, we review the relevant literature. Section 3 presents the data and section 4 outlines the empirical strategy. The results are in section 5. Section 6 concludes.

## 2. On the relationship between constraints on the executive and tax revenues

How do countries learn to tax? Recent political economy explanations have argued that the presence of political institutions placing limits on the executive power is a key long-term factor explaining fiscal capacity.[5] This argument suggests that greater constraints on the executive power have a positive effect, because they provide stronger incentives for incumbent groups to invest in tax systems. In particular, as Besley and Persson (2011) also argue, 'constraints on the executive will diminish the concern that the government is run in the interests of a narrow group' (Bardhan, 2016: 871). Such mechanisms may include 'various kinds of checks and balances including constitutional constraints on executive power, separation of powers, electoral rules, independent judiciary, free media and other accountability mechanisms for the state leadership' (Bardhan, 2016: 871). Similarly, according to Dincecco (2017: 21–22), the presence of 'an institutional player within the national government that has the formal political authority to regularly monitor state finances' is an essential mechanism for effective

[2]See Besley and Persson (2013, 2014). See also Pomeranz and Vila-Belda (2019), on the empirical, micro-level literature assessing revenue administration performance (e.g. the effects of interventions on information collection on the amount of taxes that are due).

[3]Target 17.1 focuses on *strengthening domestic resource mobilisation, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection* and adopts *Total government revenue as a proportion of GDP* as the indicator to measure its progress. See Bolch *et al*. (2022) on the prospects of domestic revenue mobilisation for poverty reduction.

[4]Executive constraints have also been a significant part of the debate on whether 'institutions rule' (Rodrik *et al*., 2004). Influential empirical articles on long-run economic development have employed executive constraints measures as a variable capturing institutional quality (e.g. Glaeser *et al*., 2004).

[5]Fiscal capacity is a product of investments in state structures, including monitoring, administration and compliance (e.g. competent tax inspectors and an efficient revenue service).

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statehood. In parliamentary democracies, such a role will be played by an effective parliament, one which the political leader cannot form, control or disband at will. Here, an effective parliament can 'regularly oversee the state's budget, including authority over taxation, the right to audit previous government spending, and the right to veto new expenditures' (Dincecco, 2017: 22). In autocracies, such checks and balances on the executive may be weaker. However, as Besley and Kudamatsu (2008) point out, even in autocracies, there may be constraints placed on the autocrat by government insiders – the 'selectorate' (Bueno de Mesquita *et al.*, 2003) – whose power does not depend on the current executive and who can remove poorly performing executives, if necessary. Thus, limits on executive power promote a *common interest* environment and may translate into new and more sophisticated forms of taxation and more effective revenue authorities (e.g. Besley and Persson, 2009).[6] The empirical literature, although still rather thin, has hitherto largely supported the hypothesis that constraints on the executive have a long-run positive impact on fiscal capacity and, in turn, on the amount of revenues collected.[7] It is questionable, however, whether one can separate the forces that lead from political institutions to the development of the tax system from those that lead from taxation to institutional change. In an authoritative survey on taxation and development, Besley and Persson (2013: 106) note: 'States that raise significant revenues will find themselves facing strong demands for accountability and representation, creating a two-way relationship between political development and the growth of the tax system. Little is yet known about this relationship. But it seems far from coincidental that states that are able to appropriate nearly half of national income in the form of taxation have also evolved strong political institutions, particularly those that constrain the use of such resources'.

The foregoing quote implies that one aspect requiring systematic analysis is the dynamics of the relationship between constraints on the executive and tax revenues: whether they co-evolve in the long run. A separate literature, mainly based on the European experience, has argued that central to how tax systems develop is also the bargaining process between the state and the citizenry. Citizens enter a *fiscal contract* with the state, which involves an exchange of tax revenues for goods and services as they have more control over its action (Bräutigam *et al.*, 2008; Levi, 1988; Moore, 2007; Ross, 2004; Tilly, 1992). This implies that there may be a feedback effect from tax revenues to political institutions placing limits on the executive power. As an increase in the amount of revenues levied comes with greater demand for scrutiny over the government actions, one can hypothesise also that increased tax revenues could in turn reinforce executive constraints, as taxpayers will demand greater accountability from the ruler.[8] This ultimately suggests that there may be a long-run

[6]Explanations focussing on executive constraints do not equate to claiming that 'democracy' leads to greater fiscal capacity. The role of constraints on the executive is separate from the role of regime types. The effect of executive constraints is about long-run aspects of state building: investing in fiscal capacity and tax infrastructures. Instead, the effect of regime types on taxation is often about short-run aspects of tax administration (e.g. tax rates and broader tax structure). Kiser and Kerceski (2017) offer a survey of the mechanisms though which the introduction of electoral competition affects tax revenues in modern states (e.g. demand for public goods). The recent literature is increasingly recognising that fiscal innovations have often occurred in non-democratic contexts. For example, Mares and Queralt (2015, 2020) explain why income tax was introduced first in countries with limited franchise extension. Because of intra-elite competition, such fiscal innovation would be more palatable to landowning elites, which saw it as a tool to rebalance in part the economic losses from the rise of manufacturing. Similarly, Andersson (2023) shows that autocracies with legislatures capable of exercising oversight are more likely to introduce a personal income tax and were able to collect more revenue from income taxes than those without the ability to monitor the government. As Collier and Hoeffler (2009) note, political institutions required to have a free and fair elections are significantly different from those placing institutionalised limits on the executive power. Holding elections is largely a short-term, focussed effort, while building a system of check and balances on the executive is establishing long-lasting processes.

[7]For example, Besley and Persson (2009) provide evidence based on conditional correlations. Ricciuti *et al.* (2019a, 2019b) provide instrumental variable estimates that greater constraints on the executive have a positive long-run effect on fiscal capacity, as captured by various measures of quality of tax administration, monitoring and compliance, on the share of revenues collected, and on the ability of states in developing economies to deliver effective financial planning.

[8]Moore (2004: 299–302) summarises the context and mechanisms behind the causal connection between the dependence of governments on broadly levied taxes and the existence of binding constraints on governments and institutionalised political representation in Western Europe. See Moore (2007) and Prichard (2015) for a discussion on the mechanisms through which taxation may result in more responsive and accountable governments in less developed economies.

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relationship between executive constraints and tax revenues such that they are cointegrated. Existing empirical literature has not investigated this proposition yet. Some empirical literature on the structural determinants of tax revenues has looked at the effect of political representation (Aidt and Jensen, 2009; Andersson, 2018; Cheibub, 1998; Timmons, 2010) or elite competition (Beramendi *et al*., 2018) on taxation. Others study the effect of taxation on regime type (Dom, 2018; Ross, 2004). Some of these studies have used historical macro data (Albers *et al*., 2020; Andersson, 2018; Beramendi *et al*., 2018). Nonetheless, no study explicitly focuses on constraints on the executive or, above all, on the dynamic aspects of its relationship with taxation.

Is the existence and nature of a long-run relationship different for different forms of taxation? The dynamic relationship between constraints on the executive and taxation may be different for different taxes because constraints on the executive, by supporting the emergence of fiscal capacity, may also have an effect on the composition of tax revenues. Investments in fiscal capacity bring greater organisational ability on the part of revenue authorities, so that states can 'earn' taxes: for example, states can increasingly substitute revenues from taxing land or its produce and taxes on the movement of goods (via customs on external borders and various types of taxes on internal sales and excises, such as salt, tobacco) with revenues from taxes levied on accounting categories (e.g. income, profits, value added), which require greater organisational effort. This should result in a transition from taxes with a narrow base to broad-based taxation over time. Indeed, Besley and Persson (2013: 56–63) show that one of the stylised facts on taxation and development is that more advanced economies tend to rely much more on broad-based taxes compared to less developed ones: this is the result of changes in the composition of revenues from trade taxes and excises towards labour income and other broad bases.[9] Since broad-based taxes are *consensual*, they require a fiscal bargain between the state and the citizens, where compliance with taxation is exchanged for institutionalised influence over the mode of taxation and the use of revenues. Hence, broad-based taxes are more likely to have a feedback effect into executive constraints rather than narrow-based taxation, so that a long-run relationship may be more likely to exist for direct taxes, such as on income, rather than trade taxes and excises.

How general is the proposition that there is a long-run dynamic relationship between executive constraints and taxation? The dynamics of the relationship between constraints on the executive and taxation may be different in different contexts because the effect of constraints on the executive on government revenues, and how fiscal bargaining develops over time, may depend on country-specific factors, such as culture and history. First, the amount and composition of revenues collected depend on the level of *tax morale* (Luttmer and Singhal, 2014), a culturally driven aspect of tax compliance (Andriani *et al*., 2021). Second, colonial heritage matters: colonial governors appointed on the basis of patron-and-client ties may be less willing to invest in fiscal capacity or enter a fiscal bargain with the citizens (Xu, 2019). Third, a civic culture based on reciprocal obligations facilitates, and sustains over time, a fiscal bargain that does not develop if such culture is lacking (Besley, 2019). Fourth, taxation preferences in different countries may reflect different preferences for redistribution (Alesina and Angeletos, 2005). Further arguments include how the structure of the economy, such as the reliance on natural resources rents, aid and the prevalence of agriculture, may adversely affect the emergence of tax systems and their functioning (see Moore, 2007). This ultimately suggests that the dynamic relationship between constraints on the executive and tax revenues may be heterogeneous across countries, because it is subject to country-specific cultural, economic and political history. This may contribute to explaining why certain countries have seen a full transition from a *domain* to a *tax* state and others have not.

In the next sections, we produce evidence on cointegration between executive constraints and taxation, testing whether a long-run relationship exists for different taxes and in different contexts.

[9]Kiser and Kerceski (2017) offer a comprehensive survey of the characteristics and structure of taxation in premodern and modern states. See Seelkopf *et al*. (2021) on the introduction and diffusion of modern taxation. See Moore (2007: 10–14) for an illustration of the historical shift of state revenues in Western Europe, from sources requiring low organisational effort to broad-based taxation, and how this relates to the possibility of fiscal development in less developed economies. In such contexts, the tax structure may struggle to shift towards broad-based taxes because they may have adopted too early institutions facilitating resistance to taxation, rather than consolidating state institutions first (D'Arcy, 2012).

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## 3. Data

Empirical research on fiscal development often faces a trade-off: choosing between a dataset with substantial cross-sectional (number of countries) and short-time dimensions and a dataset with a long temporal dimension (number of years observed) and relatively few countries. In our case, studying the dynamic relationship between executive constraints and taxation means documenting long-run phenomena that originate from institutional changes, and hence are best observed with measures spanning many decades. Consequently, our analysis focuses on measures that have substantial time series variation, for as many countries as possible. In particular, we use historical data on central government tax revenues covering the period from 1800 to 2012 obtained from the *Financing the State* dataset (Andersson and Brambor, 2019), which includes 31 countries: all countries from South America, North America and Western European countries with a population of more than one million, plus Australia, Japan, Mexico and New Zealand.[10] This dataset provides a rich set of comparable taxation measures and has the crucial advantage of providing the longest temporal coverage. The first measure we select is the ratio of central government total tax to GDP, as it measures the extent to which a state is financed by taxes. We investigate also if the dynamic relationship between constraints on the executive and taxation may be different for different taxes and, in particular, on differences between broad- and narrow-based taxes. We exploit, for this purpose, various measures on tax composition. We use the share of total taxes collected from direct and indirect taxation. Such variables broadly map into the narrow- and broad-based taxes categorisation, but they do not perfectly reflect it.[11] Hence, we focus also on the share of specific taxes, as they may more neatly reflect this categorisation. We select measures of income, consumption and trade taxes as a share of total central tax revenues. Income tax is a prime example of broad-based taxation. Instead, trade revenues are an example of narrow-based taxes. Finally, consumption taxes are a significant share of total revenues, hence it should be considered, but they may capture both narrow- and broad-based taxes.

To measure political institutions that constrain the power of the executive – expressing to what extent they provide institutionalised checks and balances – we resort to the V-Dem dataset (Coppedge *et al.*, 2020). Apart from being methodologically innovative and covering over 200 years for a global sample of countries, it provides a more granular measure of executive constraints. Checks and balances can operate through the legislative and judicial branches. The former works through parliamentary systems, which institutionally oversee and audit the state budget, and the latter through independent judicial systems enforcing the rule of law. The V-Dem dataset provides variables measuring each aspect. The *Judicial Constraints* on the executive index (*v2x_jucon*) addresses the following question: 'To what extent does the executive respect the constitution and comply with court rulings, and to what extent is the judiciary able to act in an independent fashion?'. The *Legislative Constraints* on the executive index (*v2xlg_legcon*) addresses the question: 'To what extent are the legislature and government agencies, e.g. controller general, general prosecutor or ombudsman, capable of questioning, investigating and exercising oversight over the executive?'. We use such measures individually or combined in a single index, labelled *Executive Constraints*, which is the arithmetic mean of the legislative and judicial constraints. The variables range from 0 to 100: lower values indicating lower constraints on the power of the executive (hence more executive discretion) and *vice versa*.[12]

Figure 1, where variables are averaged over the entire period, offers a visualisation of the long-run relationship between taxation and executive constraints. One apparent fact is that countries with greater constraints on the executive tend to have higher central tax-to-GDP ratios, implying that

[10]The countries included in the dataset are Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Denmark, Ecuador, Finland, France, Germany, Ireland, Italy, Japan, Mexico, Netherland, New Zealand, Norway, Paraguay, Peru, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States of America, Uruguay and Venezuela.

[11]Direct taxes include levies on land and real estate, which may have a narrow tax base. Similarly, indirect taxes include value-added taxes, which may have a broad tax base. Full details on which revenues each variable includes are in Andersson and Brambor (2019: 3–5).

[12]See the online appendix for further details.

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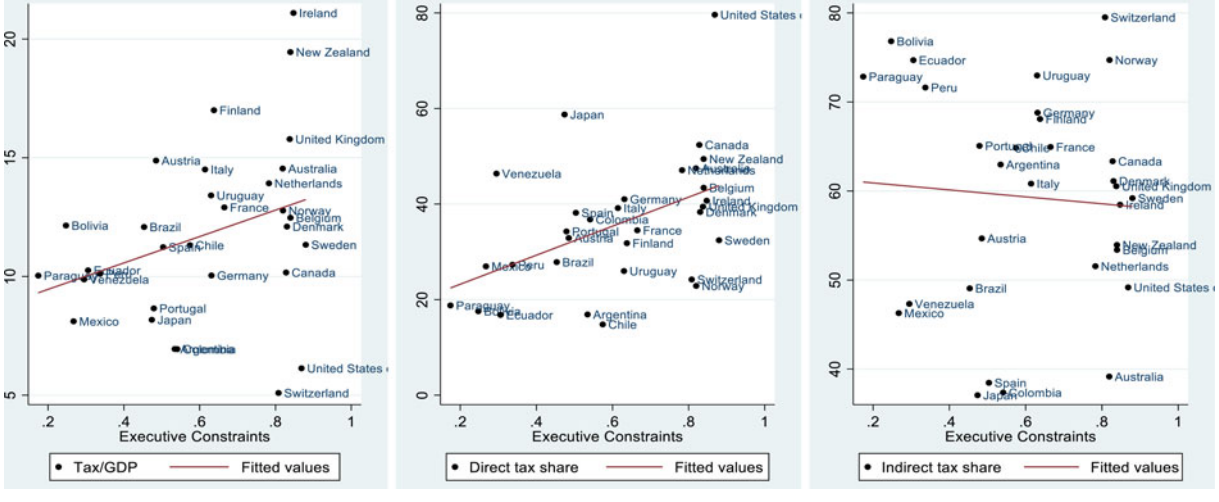


**Figure 1.** Total tax revenues, direct and indirect tax shares, and executive constraints.
*Notes*: the *Y*-axis, from left to right, reports: the *Total central government tax revenues as a share of GDP*, the *Share of total central government tax revenue from direct taxes*, the *Share of total tax revenue from indirect taxes.* See Andersson and Brambor (2019) for details.

executive constraints are associated with greater reliance of states on taxation. Second, more effective constraints on the executive tend to shift the composition of tax revenues. Countries with greater constraints on the executive tend to collect a greater share of direct taxes. *Vice versa*, there is a weak, negative correlation between executive constraints and the share of indirect taxes.[13] While Figure 1 does not lend itself to causal interpretation, it points to the fact that countries placing greater checks and balances on the executive power tend to transition from revenues from narrow tax bases (such as on trade and excises) to more broad-based taxation (such as on income).

How do the variables behave over time? Focussing on direct taxes, Figure 2 reports the time series plots for selected countries. We observe a marked increase in central government revenues from direct taxes. For most European states, they increased sharply during the 19th and especially the 20th centuries. Most evident in this respect was the United Kingdom, where the share of direct revenues increased nearly threefold between the early 19th century and late 20th century. This pattern is common to most current advanced economies (e.g. Australia, Belgium, Canada, Finland, Germany, Italy, Norway, Spain, United States). Outside the group of advanced economies, many countries showed comparable increases. Argentina, Brazil, Chile and Mexico have seen a marked increase in the share of direct revenues. In Peru, Ecuador, Bolivia, Colombia, Uruguay and Venezuela, there has been more limited (or no) increase and substantial volatility. Notably, the countries experiencing a long-run increase in the share of direct tax revenues include many resource-rich economies.

We also observe that constraints on the executive and taxation tend to move together: changes in executive constraints are followed by changes in direct tax shares, and *vice versa*. Both variables are trended (formal unit roots test, presented in the appendix, confirm non-stationarity). This is most evident in the current group of advanced economies, and it is also observable in Brazil, Chile and Mexico. Instead, it is less clear in Peru, Ecuador, Bolivia, Uruguay and Venezuela, where there seems to be significant volatility in both variables. Figure 2 ultimately suggests that fiscal and political development experiences vary to a significant extent across countries. Indeed, the historical literature recognises that the path to fiscal development can be heterogeneous because it is subject to country-specific circumstances (e.g. Yun-Casalilla and O'Brien, 2011). However, it also recognises that political motives, as shaped by institutions, are intertwined with the evolution of the tax system. Steinmo (2018) offers evidence, based on historical case studies, that fiscal capacity and tax compliance co-evolve. Sweden is an example of virtuous cycle where effective administrative institutions increased trust in the state among the taxpayers so that they would be willing to accept higher taxes (Nistotskaya and D'Arcy, 2018). Italy may be understood as partial exception to this (see D'Attoma 2018, for a historical illustration). Even the status of resource-rich economy, where the presence of a significant natural resources sector can weaken the incentive to invest in tax systems, may not necessarily limit fiscal development (see Peres-Cajías, 2015, for a case study on Bolivia; for a historical comparison of public finance in Bolivia, Chile, Peru, Norway and Sweden, see Peres-Cajías *et al.*, 2020).

## 4. Empirical strategy

We model the bi-variate long-run relationship between taxation and executive constraints accounting for the possibility that the dynamic relationship between the two may be different in different contexts. Hence, for $i = 1, 2,\ldots, N$ countries over the time period $t = 1, 2,\ldots, T$, we specify a multi-factor error structure of the form:

$$\text{tax}_{it} = \beta_i' \text{CV}_{it} + u_{it} \qquad u_{it} = \alpha_i + \lambda_i' f_t + \varepsilon_{it} \tag{1}$$

where $\text{tax}_{it}$ represents the log of the tax shares while $\text{CV}_{it}$ represents the log of the executive constraints variables. A fundamental aspect of the model is allowing the vector of parameter coefficients ($\beta_i$) to

[13]Legislative and judicial constraints, in particular, are positively correlated with the share of income taxes, negatively correlated with consumption taxes and weakly correlated with trade taxes. See the online appendix.

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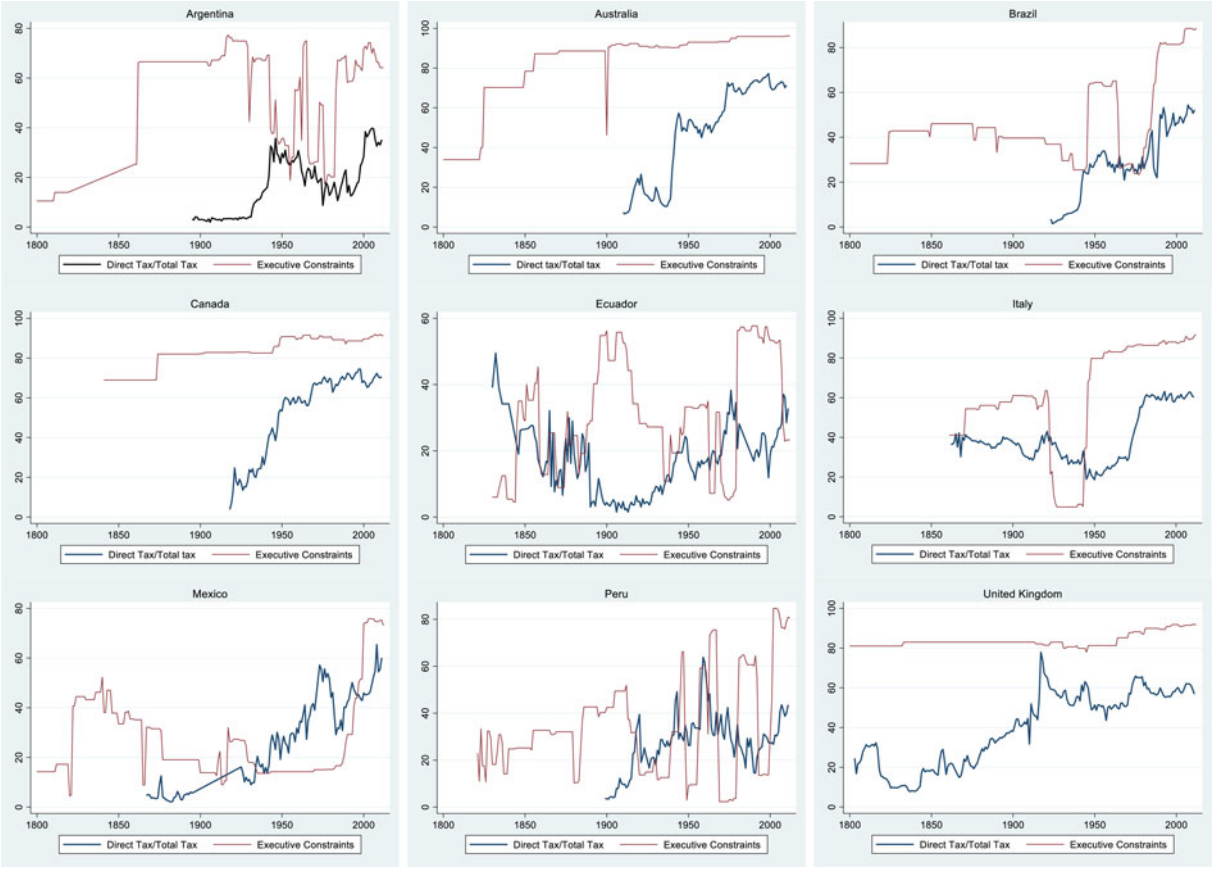


**Figure 2.** Share of direct taxes and executive constraints, 1800–2012.
*Notes*: the left-hand side vertical axis variable is the *Share of total central government tax revenue from direct taxes*. The right-hand side vertical axis variable is *Executive Constraints*.

differ across countries. This is necessary because, for the arguments presented in section 2 and considering that countries included in our sample are a mixture of developed and developing countries, the long-run dynamic relationship between tax shares and constraints may not be the same across countries.

Equation (1) also incorporates unobserved heterogeneity, modelled through country-specific fixed effects ($\alpha_i$) and a constellation of unobserved, time-varying common factors ($f_t$), with factor loadings that can differ across countries ($\lambda_i$). The country-specific heterogeneity in $\alpha_i$ may reflect time-invariant characteristics: social and cultural norms, political history – as argued in section 2 – and geography (including natural resource endowment, country size and location). The common factors address the presence of strong cross-section dependence, which is a form of unobserved, time-varying heterogeneity distinct from weaker forms of dependence (e.g. spatial correlation). Ultimately, strong cross-section dependence may be a source of endogeneity, leading to biased and inconsistent estimates (see Kapetanios *et al.*, 2011). The common factors can be represented by a combination of a limited number of 'strong' factors and an unlimited number of 'weak' factors (Chudik *et al.*, 2011). The former represents global effects, which affect all countries irrespective of their location, (initial) level of development and polity, while the latter represents local spillover effects, which may occur through geographic proximity, as well as social or economic interaction. External conflicts (regional or global), economic integration (e.g. trade agreement), structural adjustment programmes, financial crises (regional or global) and commodity price shocks are examples of common factors that may be at the origin of cross-section dependence and can affect both taxation and executive constraints. The impacts of these shocks and countries' abilities to respond differ across countries. Test results, presented in the appendix, point to pervasive cross-section dependence, thus justifying the inclusion of $f_t$ in equation (1).

Given the length of the sample period, persistence in the data raises further econometric issues. Tax revenues (and the associated tax shares) and political institutions display considerable inertia over time. For example, constitutional changes, which enact increased (or reduced) institutionalised checks and balances on the power of the executive, evolve slowly over time. This calls for a distinction between short-run and long-run impacts. A dynamic specification is thus preferable, with at least two clear advantages over its static counterpart. First, it allows for a distinction between short-run and long-run effects. Additionally, the error correction term ($\rho_i$) can be used as a supporting test for cointegration between taxation and constraints on the executive, while the error correction and long-run coefficients ($\beta_i$) can be used to test for the direction of long-run causality between variables. Second, a dynamic specification following an error correction model (ECM) easily encapsulates the feedback effects postulated by our primary hypothesis: increased accountability brought about by increased taxation (with the effect possibly stronger for direct tax shares). Thus, we employ an ECM specification of the form:

$$\Delta \text{tax}_{it} = \alpha_i + \rho_i(\text{tax}_{it-1} - \beta_i^{\text{CV}}\text{CV}_{it-1} - \lambda_i f_{t-1}) + \gamma_i^{\text{CV}}\Delta\text{CV}_{it} + \gamma_i^{F}\Delta f_t + \mu_{it} \quad (2)$$

where $\beta_i^{\text{CV}}$ in equation (2) represents the long-run equilibrium relationship between taxation and executive constraints in the model, $\gamma_i^{\text{CV}}$ represents the short-run relationship and $\rho_i$ is the error correction term indicating the speed of convergence of the economy to its long-run equilibrium. The expression in parentheses represents the potential cointegrating relationship we seek to investigate. Unobserved common factors are included in the long-run relation, which implies we will investigate an equilibrium relationship between tax shares, executive constraints and the unobservables (Banerjee and Carrión-i-Silvestre, 2017; Eberhardt and Presbitero, 2015; Eberhardt and Teal, 2013).

Following Pesaran (2006), we employ the common correlated effects mean group (CCEMG) estimator which uses (weighted) cross-section averages of the dependent ($\overline{\text{tax}}_t$) and independent variables ($\overline{\text{CV}}_t$) constructed to filter out unobserved common factors $\boldsymbol{f}$ and omitted elements of the cointegrating relationship. The estimator thus augments the country-specific OLS regressions with cross-sectional averages. Chudik and Pesaran (2015) extend the standard Pesaran (2006) approach to accommodate dynamics (feedback) from weakly exogenous regressors and find the standard

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CCEMG is subject to small sample bias in such contexts. The empirical strategy they propose to curb this bias is based on the inclusion of lags of cross-section averages:

$$\begin{aligned}\Delta \text{tax}_{it} = {} & \pi_{0i} + \pi_i^{\text{EC}}\text{tax}_{it-1} + \pi_i^{\text{CV}}\text{CV}_{it-1} + \Phi_i^{\text{CV}}\Delta\text{CV}_{it} + \pi_{1i}^{\text{CA}}\overline{\text{tax}}_t + \pi_{2i}^{\text{CA}}\overline{\text{tax}}_{t-1} \\ & + \pi_{3i}^{\text{CA}}\overline{\text{CV}}_{t-1} + \pi_{4i}^{\text{CA}}\overline{\Delta\text{CV}}_t + \Sigma_{l=1}^{p}\pi_{5i}^{\text{CA}}\overline{\Delta\text{tax}}_{t-p} + \Sigma_{l=1}^{p}\pi_{6i}^{\text{CA}}\overline{\Delta\text{CV}}_{t-p} + \varepsilon_{it}\end{aligned} \tag{3}$$

and/or the inclusion of cross-section averages of one or more further covariates (other than the constraints variables) that may help to identify the unobserved factors. Further details on this are in the appendix.

### 4.1 Co-integration and causality

The main hypothesis is a direct test for bivariate cointegration between constraints on the executive and taxation. A suitable test, one which allows for greater flexibility in cross-sectional dependence, is provided by Gengenbach *et al.* (2009). The test is based on a conditional ECM of the form:

$$\Delta \text{tax}_{it} = \alpha_i \text{tax}_{it-1} + \gamma_{1i}'\text{CV}_{it-1} + \gamma_{2i}' f_{it-1} + \sum_{s=0}^{p_i}\pi_{1is}'\Delta\text{CV}_{it-s} + \sum_{s=1}^{p_i}\pi_{2is}'\Delta\text{tax}_{it-s} + \sum_{s=0}^{p_i}\pi_{3is}'\Delta f_{it-s} + \varepsilon_{it} \tag{4}$$

The procedure in equation (4) is based on the CCEMG (Pesaran, 2006) whereby common factors $f$ are approximated by cross-section averages, including cross-section averages of lagged $\Delta\text{tax}_{it}$ and $\Delta\text{CV}_{it}$, depending on the lag-length $p_i$. The test is for a null hypothesis of no error correction (hence no cointegration) against an alternative of error correction (cointegration). The test statistic $\bar{\tau}^*$ is the average of the $t$-ratios for $\hat{\alpha}_i$, from country regressions. The individual $t$-ratios, as well as their averages, have non-standard distributions under the null hypothesis so Gengenbach *et al.* (2009) provide simulated critical values. The test is run for each CCEMG model with different deterministic terms (neither intercept nor trend, intercept, intercept and trend). Finding cointegration between tax shares and political institutions is important, as it will imply no important non-stationary variable has been omitted: any omitted non-stationary variable that is meant to be part of the cointegrating relationship will now be part of the error term, producing non-stationary residuals and failure to detect cointegration (Herzer, 2020).

An appealing feature of cointegration is that it allows testing the direction of long-run causality between variables. This is of particular interest here since we have hypothesised in section 2 that executive constraints and taxation may reinforce each other. If there exists a co-integrating relationship between tax shares and executive constraints, the Granger representation theorem (Granger, 1988) states that long-run causality must run in at least one direction (equivalent to at least one variable adjusting to maintain an equilibrium relation) and the variables can be represented in the form of a dynamic ECM. For the pair of cointegrated variables $\text{CV}_{it}$ and $\text{tax}_{it}$, we estimate:

$$\Delta \text{tax}_{it} = \rho_{1i} + \theta_{1i}\hat{e}_{it-1} + \sum_{j=1}^{K}\lambda_{11ij}\Delta\text{tax}_{it-j} + \sum_{j=1}^{K}\lambda_{12ij}\Delta\text{CV}_{it-j} + \epsilon_{it}^{\text{tax}} \tag{5}$$

$$\Delta \text{CV}_{it} = \rho_{2i} + \theta_{2i}\hat{e}_{it-1} + \sum_{j=1}^{K}\lambda_{21ij}\Delta\text{CV}_{it-j} + \sum_{j=1}^{K}\lambda_{22ij}\Delta\text{tax}_{it-j} + \epsilon_{it}^{\text{CV}} \tag{6}$$

where $\hat{e}_{it-1}$ is the error correction term $\hat{e} = \text{tax} - \hat{\beta}_i\text{CV} - \hat{d}$ constructed using the cointegrating relationship between the variables ($d$ represents deterministic terms obtained after estimating equations (5) and (6)). Equations (5) and (6) also include cross-section averages of the non-error terms in the weak exogeneity regressions. The lagged differences capture the short-run dynamics while the

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error correction term represents how far the variables are from the equilibrium relationship: with the error correction mechanism then indicating the speed of adjustment following a deviation from the long-run equilibrium (Canning and Pedroni, 2008). Each variable may react to its lagged differences, as well as lagged differences of other variables in the co-integrating relationship. The Granger representation theorem implies that at least one of the adjustment coefficients $\theta_{1i}$, $\theta_{2i}$, must be non-zero if a cointegrating (equilibrium) relationship between the variables is to hold (Canning and Pedroni, 2008). If $\theta_{1i} \neq 0$, then $CV_{it}$ has a long-run causal impact on $\text{tax}_{it}$ and, if $\theta_{2i} \neq 0$, then $\text{tax}_{it}$ has a long-run causal impact on $\text{CV}_{it}$. If both $\theta_{1i}$ and $\theta_{2i}$ are non-zero, then $\text{CV}_{it}$ and $\text{tax}_{it}$ determine each other jointly.

The ECM regressions are estimated at the country-level and empirical estimates of $\theta_i$ are investigated using standard *t*-ratios, given that all the variables in the ECM regressions (5) and (6) are stationary (Canning and Pedroni, 2008; Eberhardt and Presbitero, 2015). Following Canning and Pedroni (2008), we present the group-mean statistic (*GM* hereafter), which averages the $\theta_i$ from individual country estimations of equations (5) and (6), and the 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.

## 5. Results

This section presents the test results on the existence of a long-run equilibrium relationship between the variables, its dynamics and the direction of long-run causality.

### 5.1 Cointegration

Inference on cointegration is provided in Table 1. The results are based on the Gengenbach *et al.* (2009) cointegration test with one lag. Model 1 has no deterministic terms (no intercept or trend), model 2 includes only an intercept and model 3 includes an intercept and a linear trend. Gengenbach *et al.* (2009) tabulate critical values for different combinations of *N* (number of countries), *T* (number of years) and *m* (number of regressors). Inference is based on comparing the test statistic, $\bar{\tau}^*$, to the simulated critical values: if the absolute value of the test statistic is larger than the absolute value of the simulated critical values, we reject the null hypothesis of no error correction and hence no cointegration. The results show a clear rejection of the null hypothesis for total taxation (as a share of GDP), hence supporting the idea that there is a long-run relationship between the two. When looking at different forms of taxation, evidence of cointegration is strongest for the share of direct taxes and all measures of executive constraints. It is less clear, instead, that indirect taxes and different measures of executive constraints are cointegrated, as the test statistic is often below the 5% level. The online appendix reports cointegration tests on tax composition. For the share of income taxes, a dimension of broad-based taxation, we find evidence supporting cointegration with both legislative and judicial constraints. On the other hand, for the share of trade taxes, an example of narrow-based taxation, we mostly cannot reject the null hypothesis of no error correction across specifications. Finally, the share of consumption taxes also shows evidence of cointegration with the executive constraints measures.

### 5.2 Short- and long-run effects

Next, we focus on the dynamics of the relationship between executive constraints and taxation, as expressed in equations (2) and (3). Our first task, having observed unambiguous evidence of cointegration, is to see how taxation behaves when deviating from the long-run equilibrium. The results are in Table 2. Without exception, error correction (EC) coefficient estimates are negative and significant, reflecting the fact that executive constraints and tax revenues are cointegrated. The EC coefficient captures the adjustment towards the long-run equilibrium: what proportion of the disequilibrium in the dependent variable in one period is corrected in the next period. In this case, it means that a deviation

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**Table 1.** Gengenbach *et al*. (2009) cointegration test: taxation and executive constraints

| | Test statistic, $\bar{\tau}^*$ | 10% | 5% | 1% |
|---|---|---|---|---|
| Panel A – executive constraints | | | | |
| Total taxes/GDP and executive constraints | | | | |
| Model 1 | −2.987*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −3.198*** | −2.458 | −2.517 | −2.611 |
| Model 3 | −3.203** | −2.875 | −2.925 | −3.010 |
| Direct tax share and executive constraints | | | | |
| Model 1 | −2.954*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −3.174*** | −2.458 | −2.517 | −2.611 |
| Model 3 | −3.420** | −2.875 | −2.925 | −3.010 |
| Indirect tax share and executive constraints | | | | |
| Model 1 | −2.364*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −2.539** | −2.458 | −2.517 | −2.611 |
| Model 3 | −2.864 | −2.875 | −2.925 | −3.010 |
| Panel B – judicial constraints | | | | |
| Total taxes/GDP and judicial constraints | | | | |
| Model 1 | −2.684*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −2.790*** | −2.458 | −2.517 | −2.611 |
| Model 3 | −2.870 | −2.875 | −2.925 | −3.010 |
| Share of direct taxes and judicial constraints | | | | |
| Model 1 | −2.989*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −3.230*** | −2.458 | −2.517 | −2.611 |
| Model 3 | −3.476*** | −2.875 | −2.925 | −3.010 |
| Share of indirect taxes and judicial constraints | | | | |
| Model 1 | −2.404*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −2.505* | −2.458 | −2.517 | −2.611 |
| Model 3 | −2.842* | −2.875 | −2.925 | −3.010 |
| Panel C – legislative constraints | | | | |
| Total taxes/GDP and legislative constraints | | | | |
| Model 1 | −3.000*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −3.338*** | −2.458 | −2.517 | −2.611 |
| Model 3 | −3.261*** | −2.875 | −2.925 | −3.010 |
| Share of direct taxes and legislative constraints | | | | |
| Model 1 | −2.842*** | −1.995 | −2.065 | −2.190 |
| Model 2 | −3.129*** | −2.458 | −2.517 | −2.611 |
| Model 3 | −3.306*** | −2.875 | −2.925 | −3.010 |
| Share of indirect taxes and legislative constraints | | | | |
| Model 1 | −2.458*** | −1.995 | −2.065 | −2.190 |

(*Continued*)

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**Table 1.** (*Continued.*)

| | Test statistic, $\bar{\tau}^*$ | 10% | 5% | 1% |
|---|---|---|---|---|
| Model 2 | −2.367** | −2.458 | −2.517 | −2.611 |
| Model 3 | −2.899* | −2.875 | −2.925 | −3.010 |

*Note*: ***, **, * indicate significance at 1%, 5% and 10%, respectively. Significance will indicate rejection of the null hypothesis. $H_0$: no error correction, hence, no cointegration, $H_1$: error correction, hence cointegration. Models 1–3 refer to an ECM without any deterministic terms, with intercept and with intercept and trend, respectively.

**Table 2.** ECM estimates: total taxes, shares of direct and indirect taxes

| | Judicial | Legislative | Exec. constraints |
|---|---|---|---|
| Panel A: total taxes/GDP and executive constraints | | | |
| Long-run | | | |
| Executive constraints | 0.100 [0.095] | 0.104 [0.089] | 0.023 [0.092] |
| Short-run | | | |
| Executive constraints | −0.074 [0.067] | −0.051 [0.067] | 0.0002 [0.054] |
| EC coefficient | | | |
| $y_{it-1}$ | −0.152*** [0.016] | −0.169*** [0.019] | −0.154*** [0.016] |
| *CD* test (*p*-value) | −3.138 (0.000) | −1.986 (0.047) | −2.663 (0.008) |
| Observations (*N*) | 4,454 (31) | 4,175 (31) | 4,454 (31) |
| Panel B: share of direct taxes and executive constraints | | | |
| Long-run | | | |
| Executive constraints | 0.088 [0.232] | 0.207* [0.124] | 0.099 [0.114] |
| Short-run | | | |
| Executive constraints | 0.026 [0.040] | 0.021 [0.061] | −0.008 [0.033] |
| EC coefficient | | | |
| $y_{it-1}$ | −0.184*** [0.022] | −0.200*** [0.025] | −0.182*** [0.022] |
| *CD* test (*p*-value) | −1.708 (0.088) | −1.199 (0.230) | −1.908 (0.056) |
| Observations (*N*) | 3,907 (31) | 3,574 (31) | 3,907 (31) |
| Panel C: share of indirect taxes and executive constraints | | | |
| Long-run | | | |
| Executive constraints | −0.060 [0.292] | −0.184 [0.019] | 0.051 [0.106] |
| Short-run | | | |
| Executive constraints | 0.003 [0.049] | −0.008 [0.037] | 0.020 [0.027] |
| EC coefficient | | | |
| $y_{it-1}$ | −0.100*** [0.013] | −0.112*** [0.017] | −0.105*** [0.014] |
| *CD* test (*p*-value) | −3.859 (0.000) | −3.116 (0.002) | −4.001 (0.000) |
| Observations (*N*) | 4,304 (31) | 3,992 (31) | 4,304 (31) |

*Notes*: Results are based on an ECM for all 31 countries in the sample. The long-run and short-run averages are reported with standard errors in parentheses. '*CD* test' is the Pesaran (2015) test distributed $N(0, 1)$ under the null of weak cross-section independence (associated *p*-value in parentheses). *, **, *** indicate significance at 10%, 5% and 1% respectively.

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**Table 3.** Weak exogeneity tests

| | *GM* | *p*-value | Mean $\hat{\theta}_i$ | *t*-stat |
|---|---|---|---|---|
| Total taxes/GDP | | | | |
| Judicial constraints to tax/GDP | −2.151** | 0.031 | −0.125*** | −7.579 |
| *Tax/GDP to judicial constraints* | *0.268* | *0.789* | *0.008*** | *2.476* |
| Legislative constraints to tax/GDP | −2.220** | 0.026 | −0.149*** | −7.478 |
| *Tax/GDP to legislative constraints* | *0.357* | *0.721* | *0.006* | *1.167* |
| Executive constraints to tax/GDP | −2.240** | 0.025 | −0.143*** | −7.798 |
| *Tax/GDP to executive constraints* | *0.265* | *0.791* | *0.012* | *1.249* |
| Share of direct taxes | | | | |
| Judicial constraints to direct taxes | −2.422** | 0.015 | −0.132*** | −8.635 |
| *Direct taxes to judicial constraints* | *0.228* | *0.819* | *0.000* | *0.022* |
| Legislative constraints to direct taxes | −2.313** | 0.021 | −0.147*** | −8.202 |
| *Direct taxes to legislative constraints* | *−0.066* | *0.947* | *0.001* | *0.230* |
| Executive constraints to direct taxes | *−2.451*** | *0.014* | *−0.132**** | *−8.961* |
| *Direct taxes to executive constraints* | 0.247 | 0.805 | 0.004 | *0.721* |
| Income taxes share | | | | |
| Judicial constraints to income taxes | −2.378** | 0.017 | −0.140*** | −7.036 |
| *Income taxes to judicial constraints* | *−0.107* | *0.915* | *−0.002* | *−1.119* |
| Legislative constraints to income taxes | −2.147** | 0.032 | −0.146*** | −6.725 |
| *Legislative constraints to income taxes* | *0.008* | *0.993* | *0.001* | *0.443* |
| Executive constraints to income taxes | −2.362** | 0.018 | −0.132*** | −7.225 |
| *Income taxes to executive constraints* | *0.210* | *0.834* | *0.013*** | *2.010* |
| Share of indirect taxes | | | | |
| Judicial constraints to indirect taxes | −1.930* | 0.054 | −0.089*** | −6.365 |
| *Indirect taxes to judicial constraints* | *−0.038* | *0.969* | *0.004* | *0.717* |
| Legislative constraints to indirect taxes | −1.743* | 0.082 | −0.100*** | −5.738 |
| *Indirect taxes to legislative constraints* | *−0.183* | *0.855* | *0.003* | *0.319* |
| Executive constraints to indirect taxes | −1.875* | 0.061 | −0.096*** | −7.157 |
| *Indirect taxes to executive constraints* | *0.060* | *0.952* | *0.002* | *0.121* |
| Consumption taxes share | | | | |
| Judicial constraints to consumption taxes | −1.457 | 0.145 | −0.123*** | −4.478 |
| *Consumption taxes to judicial constraints* | *−0.138* | *0.890* | *−0.013* | *−1.402* |
| Legislative constraints to consumption taxes | −1.321 | 0.186 | −0.163*** | −5.148 |
| *Consumption taxes to legislative constraints* | *−0.344* | *0.731* | *0.001* | *0.137* |
| Executive constraints to consumption taxes | −1.381 | 0.167 | −0.155*** | −4.636 |
| *Consumption taxes to executive constraints* | *−0.137* | *0.891* | *0.005* | *0.244* |
| Trade taxes share | | | | |
| Judicial constraints to trade taxes | −1.435 | 0.151 | −0.076*** | −4.484 |

(*Continued*)

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**Table 3.** (*Continued.*)

| | *GM* | *p*-value | Mean $\hat{\theta}_i$ | *t*-stat |
|---|---|---|---|---|
| *Trade taxes to judicial constraints* | *0.185* | *0.853* | *0.001* | *0.589* |
| Legislative constraints to trade taxes | −1.540 | 0.123 | −0.086*** | −4.818 |
| *Trade taxes to legislative constraints* | *−0.367* | *0.714* | *−0.002* | *−1.672* |
| Executive constraints to trade taxes | −1.595 | 0.111 | −0.083*** | −5.206 |
| *Trade taxes to executive constraints* | *0.025* | *0.980* | *0.002* | *0.509* |

*Notes*: The rows in italics are for 'reverse causality': where causality runs from taxation to constraints variables.

of total tax revenues from the long-run equilibrium will be corrected by approximately 15% in next period. A hypothetical 'fiscal shock' would bring effects on the total amount of revenues collected that are slowly absorbed in the economy. A relatively slow adjustment of tax revenues should not come as a surprise, as this depends on the functioning of tax systems, which may be slow to react because such institutions are persistent.

Our second task is to see how executive constraints impact the amount and composition of tax revenues. While there is evidence of strong error correction, the long- and short-run coefficients of executive constraints on taxation appear statistically insignificant throughout. These estimates represent *average* effects (short- and long-run) across the 31 countries.[14] Lack of significance does not imply the absence of any significant effects. It may rather be an indication of the presence of pervasive heterogeneity across countries, where dynamic effects can be mixed and so *on average* cancel each other out. There is an important exception to this result. The estimated long-run effect on the share of total taxes from income tax is positive and significant (see appendix). This supports the idea that the effect of executive constraints works through broad-based taxation.[15]

### 5.3 Causality tests

Table 3 presents tests for the direction of long-run causality, focussing on estimates from equations (5) and (6). The group mean test allows us to ask whether the long-run causal effect is zero on average for the panel. *GM* denotes the group mean statistic (which is the average of country-specific *t*-ratios on the disequilibrium term, distributed as *N(0,1)*). The test statistic is for the null of 'no causal impact', which in our case can be interpreted as the variable not adjusting to maintain the long-run equilibrium. While primary interest is in the *GM* statistic, we also report the robust $\hat{\theta}_i$ estimate and its associated *t*-statistic. At best, the panel robust $\hat{\theta}_i$ complements the *GM* statistic. A combination of high *t*-statistic on the average $\hat{\theta}_i$ coefficients in the regular equations and a low *t*-statistic (below 1.96) in the 'reverse causality' equations can be interpreted as evidence of a long-run causal relationship from executive constraints to tax variables.

There is clear evidence that long-run causality runs from constraints on the executive to tax shares. This result is most evident for direct tax shares, and, specifically, for income tax shares. Instead, we find very little evidence that causality runs from taxation to executive constraints. In particular, there is some evidence of bi-directionality only for a measure of total taxes and income taxes, but no evidence for consumption or trade taxes. In sum, the results favour the hypothesis that causality runs from executive constraints to taxation, and broad-based taxes specifically. However, we cannot rule out the possibility of bi-directionality. The lack of clear evidence of causality running from taxation

[14]We provide long-run average (LRA) estimates, obtained by averaging ECM coefficients first before computing the long-run average. The LRA is preferred to the average long-run (ALR) estimates, obtained by computing the long-run coefficient in each country before averaging them, since this is more sensitive to outliers.

[15]We extend the analysis in three ways: (i) by allowing for longer dynamics; (ii) by including historical macroeconomic variables; (iii) by broadening the sample. The results, available in the online appendix, are largely similar.

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to executive constraints may not imply the absence of any significant long-run causality, but rather reflect the presence of pervasive heterogeneity across countries, where a feedback effect from tax revenues to political institutions may or may not materialise depending on context-specific conditions.

## 6. Conclusions

Political institutions placing constraints on the executive power can positively affect the ability of states to collect revenues. In turn, the emergence of new forms of taxation can itself increase the pressure on governments to become more accountable. This paper has studied the dynamic aspect of this relationship, offering panel time series evidence that allows for cross-sectional dependence and unobserved heterogeneity at country level of different forms, whether it is fixed effects or parameter heterogeneity. We find that executive constraints, whether they are judicial or legislative, and tax revenues are cointegrated: there is a long-run relationship between the two. While in the short-run executive constraints or tax revenues can drift apart, this will be temporary because they tend to co-evolve. We also find that the existence and nature of a long-run relationship may be mainly related to the emergence of broad-based taxation. Evidence of cointegration is strongest for variables capturing the share of revenues from direct taxes, such as the income tax, much weaker for indirect tax revenues, and absent for trade taxes. Moreover, we find evidence that long-run causality runs mainly from executive constraints to taxation. This is most evident for direct taxes. Finally, our results also point to the possibility that the dynamic relationship between executive constraints and taxation is also subject to country-specific conditions. These results hold for a sample of 31 advanced and emerging economies for the 1820–2012 period. Whether a long-run relationship between executive constraints and taxation extends to a global sample is a question left for future research.

The above findings are policy relevant. With respect to SDG17 Target 1, which requires strengthening domestic resource mobilisation, our findings imply that institutions providing effective checks and balances on the executive power can be an important political condition for progress on this target. Much donor support for revenue administrations development tends to focus on technocratic solutions, such as upgrading the infrastructures or reforming recruitment practices in the public sector. While this is important, our findings suggest that a technical fix alone may not be enough, if political institutions providing the incentive to invest in fiscal capacity are missing. Our findings are also relevant to promoting 'effective, accountable and transparent institutions at all levels', as SDG16 Target 16.6 requires. The emergence of revenues from broad-based taxation reinforces institutions keeping state leadership accountable, contributing to their long-term consolidation. Hence, the effect of mobilising domestic revenues can have benefits that go beyond the immediate positive economic effect on public finance. If the intent of the Sustainable Development Goals was that different targets should work in synergy, this is one case where this may succeed.

**Supplementary material.** The supplementary material for this article can be found at https://www.wider.unu.edu/sites/default/files/Publications/Working-paper/PDF/wp2022-4-supplementary-material-appendix-article.pdf.

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