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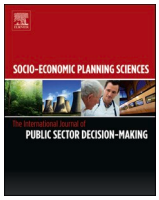

Convergence analysis of the tax burden and economic development in OECD countries: a causality analysis

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ABSTRACT

Economic development strongly influences both the level and scope of the tax burden, while the level and structure of taxation can, in turn, decisively influence economic development. Similarly, the convergence processes of both phenomena might be interrelated. This paper analyses the convergence of both the tax burden and economic development, as measured by the tax level ratio and GDP per capita, respectively, in OECD countries over the period 1995–2022. To analyse the possible interdependence between the tax burden and economic development, we use a recursive panel analysis and control for heterogeneity with fixed effects to estimate the time evolution of the convergence rates of both variables. Our findings show that the speed of convergence of the tax burden is much higher than that of GDP per capita. During the recessionary phase of the economic cycle, the speed of economic convergence increases because better positioned countries experience a larger decline in growth than those initially in a worse position; whereas during the expansionary phase of the cycle, the opposite holds. The Granger causality test confirms that convergence in GDP per capita influences convergence in the tax burden, but not vice versa.

1. Introduction

The role of the tax system in a modern state can hardly be overstated. The scope and intensity of the public sector in the economy depend heavily on both the state's tax capacity and its effective use; as Benitez et al. ([1], p. 4) highlighted, "tax capacity is the cornerstone of state capacity". For this reason, the level of taxation (measured by the tax burden) serves as a key indicator of the size of the public sector. Thus, understanding the magnitude and trajectory of the tax burden is crucial for assessing the role of the public sector in the economy and its potential impact on allocation, distribution, and economic stability.

Despite the widespread use of tax burden ratios, numerous methodological pitfalls affect this indicator, which, if left unaccounted for, may lead to non-homogeneous cross-country comparisons. The analysis of the tax burden has traditionally been central to studies on the dynamics of tax systems. Over time, wide contrasts have been observed in taxation levels across the world. These differences are particularly noteworthy when countries with highly divergent levels of development are compared, but they are also significant within the group of developed countries, especially among members of the Organisation for Economic Co-operation and Development (OECD).

Beyond its academic relevance, analysing taxation trends is intrinsically important, as it signals the public sector's capacity to address social challenges. Research into the determinants of the tax burden is increasingly relevant in the current context, as public sector challenges multiply and social demands expand. Economic development strongly influences the sustainable level of the tax burden, while, the level and structure of taxation, in turn, can decisively shape the process of economic development.

The body of empirical research addressing these questions since the mid-20th century is vast. Although considerable evidence has been amassed, we cannot say that these questions have been conclusively resolved, especially in a rapidly evolving and non-linear international landscape. A simple review of the data reveals that observed trends toward convergence in tax ratios and structures may be partially reversible, as the experiences of individual countries frequently challenge

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projections and expectations. In this context, our study aims to analyse the convergence of the tax burden in OECD countries over the period 1995–2022, with a focus on whether this convergence is connected to economic development. In other words, is there evidence of a relationship between economic development and the tax burden? Can it be empirically demonstrated that the convergence of tax policies influences the process of economic development convergence?

To achieve this objective, the paper is structured as follows. Section 2 reviews of the relevant literature concerning the convergence of these variables and their interrelationship; Section 3 describes the scope and objectives of the research, with an emphasis on key conceptual aspects of the tax burden and economic development; in the following sections, the methodology and results are discussed; finally, the main conclusions of the study and directions of future research lines are outlined.

2. Related literature and contribution

2.1. Tax burden convergence

Fiscal convergence has long been the subject of intense academic debate in recent years. In this context, Esteve et al. [2] analyse the convergence in tax burdens recorded in the European Union (EU) during the period 1967–1994. Applying sigma and beta convergence, they observe convergence between 1979 and 1994, and divergence from 1967 to 1979. Similarly, Sosvilla-Rivero et al. [3] also employ the traditional cross-sectional convergence indicators to examine the convergence of tax burdens in 14 EU nations between 1965 and 1995 and reached similar conclusions, noting convergence from 1967 to 1974 and after 1984, with divergence between 1974 and 1984.

Delgado [4,5] extended this research by examining the components of fiscal pressure and the tax mix from 1965 to 2005. His studies suggest overall convergence in total fiscal pressure and tax mix, particularly between 1975 and 1990, driven mainly by taxes on goods and services [4]. Moreover, Delgado [5] employed cluster analysis to identify groups with similar fiscal characteristics based on various tax indicators. In another study, Delgado and Presno [6] also examined the disaggregated tax burden and incorporate the tax mix into the analysis for the EU-15 over the period 1965–2005. They also examined the β-convergence by applying the unit-root and stationarity tests with structural breaks. Using Germany, the United Kingdom and the European average as benchmarks, the results showed limited convergence, largely confined to income and profits taxes and to taxes on goods and services. Using the same reference benchmarks, Delgado and Presno [7] applied stationarity and unit-root tests to analyse the convergence of tax burdens in the EU-15 over the period 1965–2004. Their findings indicated that fiscal pressure in the EU had not converged despite harmonisation efforts, with long-run convergence observed only for the United Kingdom and Germany.

Within the OECD framework, Becker and Elsayyad [8] introduced a bilateral similarity index to assess tax-system similarity based on a country's characteristics and found modest convergence in tax structures.

Later, Vintilă and Tibulca [9] used cluster analysis to examine fiscal pressure and tax mix convergence in the EU and found a significant trend towards convergence among member states.

At the local level of government, Delgado, Presno et al. [10] analysed the convergence of local taxation in the EU-15 over 1975–2015. Sigma convergence yielded mixed results, convergence in 1975–2015 and 1995–2015, but divergence in 1975–1994. Under a club-convergence approach, the countries were grouped into two clubs in the full sample, while in the sub-periods they identified two and three clubs, along with divergent countries.

With regard to environmental taxation, Delgado et al. [11] analyses its evolution and main components—energy and transport taxes—in the EU over the period 1995–2016 using a club-convergence approach. The findings revealed three convergence clubs for total environmental taxation and two for its subcategories when measured as a share of GDP. From a tax-structure perspective, two clusters emerge for total environmental taxes, three for energy taxes, and one for transport taxes, indicating overall convergence in the latter. Overall, the results suggested a substantial degree of convergence in environmental taxation across the EU.

Using state-level data and micro-level tax returns over the past three decades, Biswas et al. [12] examined how tax policies aimed at reducing income inequality affected economic growth in the United States. They found that reducing inequality between low- and median-income households was associated with stronger growth, whereas policies targeting inequality between median- and high-income groups hindered growth. These asymmetric effects operate through several supply-side mechanisms, including labour supply, small business activity, and changes in consumption demand.

Examining international tax competition, Winner [13] analyses 23 OECD countries from 1965 to 2000, with focus on small open economies and found that capital mobility lowers capital taxes but raises labour taxes, as well as small open economies tend to levy lower taxes than larger ones. Furthermore, he found evidence of an increase in tax competition rather than convergence between the countries since the mid-1980s. Similarly, Devereux et al. [14] highlighted the presence of tax competition, rather than convergence among EU and OECD countries. They concluded that OECD member states actively compete on statutory tax rates, average effective tax rates, and marginal effective tax rates, with the first two categories showing the strongest competition.

Slemrod [15] analyses corporate tax convergence across countries using cross-sectional data and the ordinary least squares (OLS) method and found that corporate tax rates were independent of a country's revenue needs.

Other authors such as Regis et al. [16] and Chen et al. [17] provided complementary evidence of convergence in statutory corporate tax rates across regions using the [18] methodology. In Europe, Regis et al. [16] identified four distinct convergence clubs, while Chen et al. [17] analysed 15 Asia–Pacific countries over 1980–2014 and found significant dynamic convergence with three clubs. In both studies, countries within each club progressively narrowed tax rate differences over time.

In a related study, Delgado, Fernández-Rodríguez et al. [19] examined effective corporate tax rates in the European Union using a club-convergence approach, identifying three convergence clubs highlighting notable differences between statutory and effective tax rates, which underscore the importance of fiscal incentives as well as the substantial gap between these two types of tax rates across many European countries.

Apergis and Cooray [20] investigated the convergence of tax revenues in a panel of 11 countries from the Association of Southeast Asian Nations (ASEAN), Asia–Pacific, and Oceania over the period 1990–2012. Applying the nonlinear, time-varying factor model developed by Phillips and Sul [21], they did not find full convergence, but rather convergence clubs in four categories of tax revenues. Applying the methodology of Phillips and Sul [21] together with a preliminary sigma convergence study, Delgado and Presno [22] analysed fiscal convergence in 15 EU countries between 1975 and 2011 and examined the tax burden and the tax mix using OECD subdivisions. The results indicated sigma convergence in all cases, albeit to varying degrees, and revealed the existence of convergence clubs, with differences between the overall sample and the two sub-periods 1975–1994 and 1995–2011. At the same time, Bustos et al. [23] applied cluster analysis to study the effective tax rates in the EU between 2006 and 2014 and identified convergence during periods of economic expansion and divergence during recessions.

Godbout and Robert-Angers [24] analysis of OECD countries from 1981 to 2018 revealed convergence in both tax burden and tax structures for the majority of 24 examined countries, although Canada was noted as an exception to this trend. On a broader scale, Van Ganzen [25] analysed the determinants of tax mix composition and convergence in a

panel of 30 EU and OECD countries over 1980–2019, employing linear regression techniques. His results suggest that tax structures are converging and shifting away from personal income taxation towards more regressive sources of revenue, primarily driven by EU membership. Nevertheless, in Central and Eastern Europe, tax systems remain relatively low and regressive.

According to Enache [26], "although the tax wedge has changed quite substantially in some countries over time, the average OECD tax burden on labour has dropped just by 1.4 percentage points over the past two decades. In 2000, the average OECD tax wedge was 36.2 percent, compared with 34.8 percent in 2023. However, the lowest level was reached in 2009 after the financial crisis".

Recently, several OECD countries have introduced reforms to personal income tax and social security contributions to support labour-market participation and address demographic changes ([27], pp. 23 and 35).

2.2. Economic convergence

As far as the study of economic convergence is concerned, it has also given rise to an extensive body of literature, following the seminal articles by Solow [28], Barro and Sala-i-Martin [29], and Mankiw et al. [30]. According to the Solow–Swan neoclassical growth model, the concept of convergence implies that less developed economies can catch up with more advanced ones. Empirical evidence from Barro and Sala-i-Martin [29] indicated that convergence, particularly in developed regions, could reduce territorial disparities, although Baumol [31] cautioned that such effects were often confined to industrialized economies. Subsequent studies emphasised that the outcomes of convergence depended on institutional quality [32], innovative capacity [33], and investment in human capital [30]. Sachs and Warner [34] presented evidence that a sufficient condition for convergence was that poorer countries implemented reasonably efficient economic policies, particularly open trade and the protection of private property rights. Conversely, Lin [35] argued that an economy's industrial structure was shaped by its endowment structure, and that governments should focus on upgrading endowments rather than imposing incompatible industrial structures. Similarly, other authors, such as Yin et al. [36], analysed whether the common policies of the European Union succeeded in fostering economic convergence among its member states during 1960–1995. To this end, they employed measures of sigma and beta convergence. Their results indicated overall economic convergence, with a slight divergence in the 1980–1985 subperiod.

In one of the first country-level analyses of the current new EU member states, Kocenda [37] applied unit-root tests to groups of countries organised according to trade and geographical criteria and identified convergence in real output growth rates for five Central European nations — the Czech Republic, Hungary, Poland, Slovakia, and Slovenia — during 1991–1998. Meanwhile, in a wider investigation that encompassed 26 post-communist countries between 1970 and 1998, Estrin et al. [38] employed a time-varying parameters method and reported no evidence of convergence towards Western Europe, except in the cases of Hungary, the Czech Republic, and Slovakia.

Kutan and Yigit [39–41] examined both real and nominal convergence of ten new EU member states with respect to the old EU-15 during the pre-accession years (1993–2004), drawing on a range of economic indicators. Their findings revealed notable evidence of convergence in industrial output. In addition, their estimates indicated substantial progress in real convergence with Germany, the EU's largest economy. In contrast, the analysis by Brada et al. [42], which considered real and nominal convergence in the EU over a longer timeframe, did not yield any definitive conclusions.

In a subsequent paper, Matkowski and Próchniak [43] provided evidence of steady progress in real economic convergence between the new EU member states in Central and Eastern Europe (CEE-8) and the old EU-15. Employing a cross-sectional approach, they confirmed the presence of beta convergence of the CEE-8 countries relative to the EU members, although sigma convergence proved less marked or even absent during certain periods.

Cavenaile and Dubois [44] explored the convergence process within the European Union. Specifically, they analysed the convergence of the new Central and Eastern European entrants alongside the fifteen Western countries during 1990–2007. Using a panel method applied to the convergence equation developed by Mankiw et al. [30] from the Solow model, they emphasised the presence of heterogeneity within the Union and demonstrated that both the new members and older EU states can be regarded as belonging to distinctly separate convergence groups.

Some studies, such as Monfort et al. [45] and Borsi and Metiu [46], questioned overall income convergence and suggested the existence of convergence clubs, which reflect persistent differences between old and new EU member states. Monfort et al. [45], in particular, examined real convergence in GDP per worker in the enlarged EU using econometric techniques based on factor analysis, and identified two clubs within the EU-14 and the new member states. Similarly, Borsi and Metiu [46] applied the Phillips and Sul [21] framework to study convergence in the enlarged EU from 1970 to 2010 and found several clubs converging toward different steady states.

Crespo et al. [47,48] noted that although population ageing might slow economic growth in Europe, improvements in education and investment in human capital could help offset this effect. In particular, Crespo et al. [47] focused on the dynamics of income convergence between CEE countries and Western European economies over 2010–2070. Their findings indicated that enhancements in human capital played a crucial role in fostering convergence, with projected per capita income levels by 2070 considerably higher under the scenario of additional investment in education and skills. Subsequently, Crespo et al.[48] went on to demonstrate that prevailing demographic trends were likely to slow the pace of income convergence across European countries. Their analysis further suggested that narrowing the educational attainment gap between the new EU member states and the rest of the Union, alongside higher labour force participation, could accelerate convergence in incomes.

Cieślik and Wciślik [49] examined whether real GDP per capita in the CEE-8 economies had converged towards the levels observed in the EU-15. Drawing on the convergence-testing framework of Phillips and Sul [5,21,50], which explicitly incorporates cross-country heterogeneity, their analysis provided a nuanced picture. While no clear convergence patterns were detected within the EU-15, evidence points to convergence among the CEE-8 themselves. In contrast, the hypothesis of convergence of the CEE-8 as a group towards the EU-15 was not supported, although signs of catching up with the two largest economies, Germany and France, was observed.

Other authors, such as Isla-Castillo et al. [51], have analysed territorial economic cohesion in EU regions and have found convergence speeds of 7–11% without spatial dependence, and 3–8% when spatial dependence is accounted for. In parallel, Amendola [52], drawing on the heterogeneity of income distribution, has explored economic convergence. Using data from 25 countries from 1980 to 2019, he finds that the richest segments converge more than the poorest, and that this difference has intensified in recent decades, highlighting difficulties for low-income groups in improving their relative standard of living.

2.3. Tax convergence and economic convergence

The study of the relationship between the size of the public sector—whether in terms of expenditure or revenue—and the level of economic development has long held a prominent place in the analytical field of public finance. The usual explanations of Wagner's law generally assume that an increase in GDP per capita leads to greater demand for collective goods. However, it is also argued that the allocation of public sector resources can act as a driver of economic development. In this regard, Gaspar et al. [53] estimate that once a country exceeds the 13%

threshold in its tax burden ratio (excluding social security contributions), the probability of an acceleration in economic growth increases significantly. Per capita income has traditionally been considered a 'good predictor' of the tax burden ratio ([54], p. 111). However, as Musgrave [54], p. 114) himself cautioned, "the good fit [of linear regression] obtained for the sample as a whole may … be misleading. It does not reflect a continuous trend, but rather a comparison between the averages for the high- and low-income groups".

Among the numerous theoretical contributions aimed at explaining the dynamics of tax structures throughout the development process, two basic questions have attracted sustained attention since the nineteenth century in the study of the relationship between the tax system and development: first, the determinants of the level of the tax burden and its evolution over time; and second, changes in the structure of public revenues throughout the development process, with the aim of identifying a representative model of a tax system for groups of countries at the same stage of development.[1]

As Musgrave ([54], p. 121) states, "Economic factors influence the development of the tax structure in two ways. As the structure of the economy changes with economic development, the nature of tax bases also changes, and with it the tax 'handles' to which the revenue system can be attached". Economic factors thus play a fundamental role in shaping the fiscal structure of countries, but this structure is also influenced by political and social forces ([54], p. 128).

In their review of the history of taxation over 5000 years, Anceau and Bordron ([55], p. 16) point out that "taxation is also a reflection of the world at a given moment. It has evolved over time and across countries, depending on the stage of development of societies, the strategies and needs of states, and the dominant ideology … The history of taxation bears witness to the creativity and inventiveness of the state, but also to its capacity for adaptation".

Undoubtedly, the level of GDP per capita constitutes a first-order determinant in the establishment of taxation. Only when GDP per capita exceeds the subsistence threshold can taxes be levied on the portion of income available to meet needs other than subsistence. Similarly, this variable, as an indicator of the level of development, is associated with a given availability of tax handles.

The OECD [56] carried out an analysis of the relationship between tax revenue and GDP over the period 1980–2021. The results showed that, in the long run, tax revenues grew at the same pace—and with the same volatility—as GDP for the whole OECD.

Wang [57] employed time-series and cluster analyses to examine the convergence of the tax burden and per capita GDP among Taiwan, China, and OECD countries. The results indicated that, although no significant relationship was found between integration and overall fiscal convergence, the China–Taiwan–Korea group steadily moved towards a common model during the 1970s, 1980s, and 1990s. While fiscal convergence was observed within the group, no pairwise convergence was detected.

Afonso and Furceri [58] used panel data from OECD and EU countries to show that tax revenues, particularly indirect taxes, hindered growth. Blanco and Delgado [59] applied quantile regression to EU countries and found that the tax burden slowed economic growth. In turn, Dabla-Norris and Lima [60] concluded that increasing taxes lowers output and employment, thereby restraining growth.

However, Gurnak [61] found that higher effective tax rates fostered economic growth in underdeveloped and developing countries. Similarly, Husman and Brezeanu [62] reported consistent results for the and [63], applying an ARDL model to South Africa, also supported this finding. Along the same lines, Ho et al. [64] strengthen this evidence by showing that, in the context of greater trade openness, higher taxes were associated with economic growth across 29 developing countries between 2000 and 2020. Using panel data from 31 Chinese provinces (2010–2022), Zhang et al. [65] further confirmed this positive relationship.

Beyond assessing the overall impact of the tax burden on economic growth, several scholars have examined the differentiated effects of specific tax categories on such growth. Kneller et al. [66] distinguish between distortionary taxes (on income and property) and non-distortionary taxes (on consumption), concluding that the former reduce growth while the latter do not. Widmalm [67] examined economic growth between 1965 and 1990 in a cross-section analysis of 23 OECD countries and found that personal income taxes were negatively correlated with growth, whereas consumption taxes tended to have a growth-enhancing effect. Padovano and Galli [68] found that higher marginal effective tax rates and greater tax progressivity negatively affected economic growth in 25 industrialized countries between 1970 and 1998. Similarly, Gentry and Hubbard [69] concluded that tax progressivity discourages entrepreneurial activity. Research by Lee and Gordon [70] suggested that corporate taxes reduce productivity and are negatively associated with economic growth across multiple countries and time periods. Later, Macek [71] evaluated how different taxes influenced economic growth in the OECD between 2000 and 2011by employing regression analysis and the neoclassical growth model of Mankiw et al. [30]. The findings suggested that, to foster growth, corporate and personal income taxes should be reduced, and that the loss of income tax revenues should be compensated by higher indirect taxes.

Durović-Todorović et al. [72], using panel data from 1975 to 2010 for 25 rich OECD countries, also found that both corporate and personal income taxation negatively influence economic growth. However, it is important to note that taxes on property and gross domestic product are not significantly correlated at the OECD level [71,72]. While Baiardi et al. [73] found a negative correlation between overall tax revenue and economic growth, there was no robust relationship between tax composition shifts and growth. In contrast, Stoilova [74] and Stoilova et al. [75] found that value-added tax, property taxes, and income taxes (personal and corporate) appear to support economic growth. Kawano et al. [76] have examined personal, corporate, and value-added tax rate changes through alternative definitions of policy shocks and employ both traditional and more recent estimation techniques that address staggered treatments. Using panel data and different methods, they have found that the results are imprecise and do not provide strong evidence that changes in tax rates have a significant effect on national income in the medium term.

2.4. Contribution

As described in this section, studies on both economic convergence and the tax burden are abundant and rely on a wide range of methodologies. However, despite the fact that the literature on both economic development and tax burden convergence is extensive, relatively few studies specifically examine the dependency relationship between them, particularly about their joint convergence. Indeed, despite the variety of methodologies applied in previous research, the question of whether convergence in GDP per capita influences convergence in the tax burden, or vice versa, remains largely unexplored.

To shed light on this gap and reconcile divergent findings in the literature, this study conducts a focused analysis of OECD countries over 1995–2022, examining economic development, tax burden, and their interdependence within the convergence process, both in terms of dispersion (sigma convergence) and speed (beta convergence). We specifically test whether the speed of GDP per capita convergence affects the speed of the tax burden convergence, and vice versa, by applying the

[1] An overview of the main historical contributions on the relationship between economic development and tax structure can be found in Fuentes Quintana [94] and Domínguez Martínez and Gómez Sala (1995) [95]. Musgrave's work (1970), the second part of which is dedicated to the relationship between economic development and the public sector, is a fundamental reference.

Granger causality test. This allows us to assess not only the evolution of each phenomenon but also their potential dynamic interrelationships over time. Such an integrated approach is less common in previous studies, which typically examine both processes separately.

Secondly, the study adopts a novel methodological approach by using a recursive fixed-effects panel data analysis to estimate the temporal evolution of convergence speeds. This dynamic approach framework provides a more nuanced understanding of how fiscal and economic convergences varie across different macroeconomic contexts, thus overcoming the limitations of the static estimates commonly found in the literature.

Thirdly, the study provides original empirical evidence showing that the speed of convergence in the tax burden is significantly greater than that of GDP per capita, suggesting that tax systems tend to align across countries more rapidly than their levels of economic well-being. Furthermore, convergence exhibits a pronounced cyclical component: it accelerates during recessionary phases and slows during expansionary periods, with a stronger emphasis on economic convergence than on fiscal convergence.

Finally, the Granger causality analysis provides a significant contribution by demonstrating that the speed of convergence in GDP per capita conditions the speed of convergence in the tax burden, but not the other way around. This finding clarifies the predominant direction of influence between the two processes and opens new avenues to further research of the mechanisms through which economic development shapes the evolution of tax systems.

3. - Data and methodology

In this study, we consider the tax burden and GDP per capita as the main variables of analysis, within the OECD context over the period 1995–2022. The tax burden[2] is measured by taking the total tax revenues received as a percentage of GDP, and GDP per capita[3] is expressed in constant 2015 US$.

The present study follows the criteria of the OECD ([77], p.326) regarding the definition of a tax: 'the term “taxes” is confined to compulsory unrequited payments to the general government or to a supranational authority. Taxes are unrequited in the sense that benefits provided by the government to taxpayers are not normally in proportion to their payments'.

Likewise, following the criteria of the OECD ([77], p.327) social security contributions are included as taxes: “Compulsory social security contributions paid to the general government, are treated here as tax revenues. They may, however, differ from other taxes in that the receipt of social security benefits depends, in most countries, upon appropriate contributions having been made, although the size of the benefits is not necessarily related to the amount of the contributions. Better comparability between countries is obtained by treating social security contributions as taxes”.

The choice of this period 1995–2022 is due to several reasons. First, it covers a broad period during which there were distinct phases in the trajectory of economic activity: the Great Moderation, the Financial Crisis, the Great Recession, the Pandemic Crisis, and the onset of the post-COVID recovery.

Given the objective of this paper, we have opted for beta convergence analysis to determine the rate at which OECD countries should progress so that those starting from a lower position grow more, while those starting from a higher position grow less. Sigma convergence is applied to provide a descriptive view of discrepancies or inequalities over time. In relation to beta convergence, we describe the advantages and disadvantages of applying cross-sectional analysis versus a data panel approach, including its recursive analysis. To examine the possible interdependence between the tax burden convergence and economic development, we use the Granger causality test.

When we refer to convergence, we usually refer to economic convergence, understood as the tendency for discrepancies between the income levels or GDP per capita of regions or countries to decrease over time. There are various general approaches to convergence and numerous indicators that can be used for its quantitative approximation.

The OECD [78] provides a summary of the methods used to measure convergence in tax levels, which have been informed by the methodological approaches developed within the framework of economic growth models [29,30]. The distinct nature of the variables related to economic growth and taxation cannot be overlooked when applying these methods. In summary, three basic approaches can be used:

a) Sigma convergence: measures how the dispersion among the economies within a group of countries evolves over time, based on a set of indicators.[4]
b) Beta convergence: measures the rate at which less developed economies converge towards more advanced ones.
c) Gamma convergence: measures changes in the ranking of countries over time.

Regarding the tax burden, Tanzi ([79], p. 4) considers the 'most common' method to be the comparison of a country's tax burden in each year with the highest level reached by that country during the period analysed. Godbout and Robert-Angers [24], for their part, propose the following indicator: 100 × [(tax burden of a country/average tax burden of the OECD) – 1].

3.1. Sigma convergence: static and dynamic analysis

While beta convergence captures growth differentials, sigma convergence measures the reduction in the dispersion of variable levels between regions or countries over time.

In the literature, static analysis of sigma convergence refers to the calculation of the aforementioned measures using a cross-sectional approach. Following Gömleksiz et al. [80], dynamic convergence analysis involves examining discrepancies or inequalities over time. One possible approach is to use the following deterministic trend model, where I_t refers to the value of the indicator in period t:

$$I_t = \alpha + \gamma t + \varepsilon_t \quad (1)$$

Following Isla-Castillo et al. [51], Fig. 1 illustrates a sigma convergence trend over time (left-hand graph), which, in turn, is positively associated with economic development (right-hand graph). Sigma convergence implies a reduction in dispersion and inequality over time and simultaneously contributes to higher levels of economic development—such as increased territorial cohesion in the case of regions or countries within an economic union.

To investigate whether measures of dispersion across economies decline over time, a range of indicators can be used, such as the standard deviation, the coefficient of variation, the absolute deviation from the mean, the Gini coefficient, the Atkinson index, the Theil index and rank

[2] The data are available at https://data.oecd.org/tax/tax-revenue.htm.

[3] Gross domestic product has been divided by the general population to achieve a per capita estimate. This indicator is expressed in constant prices, meaning the series has been adjusted to account for price changes over time. The reference year for this adjustment is 2015. This indicator is expressed in United States dollars. The data are available at https://databank.worldbank.org/metadataglossary/world-development-indicators/series/NY.GDP.PCAP.KD.

[4] Barro and Sala-i-Martin [29] demonstrated that sigma convergence and beta convergence are related, with beta convergence being a necessary but not sufficient condition for achieving sigma convergence.

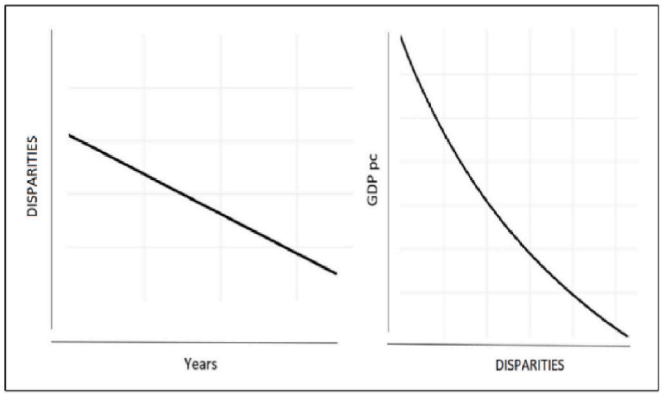

Fig. 1. Sigma convergence and territorial cohesion (GDP pc).
Source: Isla-Castillo et al. [51].

measures.[5]

3.2. Beta convergence: cross section analysis

This concept has a solid theoretical foundation in the Solow growth model, where diminishing returns to capital imply that economies grow faster at low levels of capital accumulation [28]. Beta convergence occurs when poorer countries (or regions) experience higher growth rates than richer ones, thereby effectively 'catching up' over time [29,30].

The existence of this type of convergence implies an inverse relationship between the growth rate and the initial level of GDP per capita of the regions or countries.[6] To estimate the speed of convergence in both the tax burden and economic development, using a cross-sectional analysis of the 38 OECD countries, the following equation—based on the specification introduced by Barro and Sala-i-Martin [29]—was applied:

$$y_i = \alpha + \gamma x_i + v_i \tag{2}$$

$$y_i = ln\left(\frac{Y_{i,T}}{Y_{i,0}}\right)$$

$$x_i = ln\left(Y_{i,0}\right) - \frac{1}{N}\sum_{i=1}^{38} ln\left(Y_{i,0}\right)$$

$$v_i = \gamma \ln\left(Y_i^*\right) + \varepsilon_i$$

$$\varepsilon_i \sim N\left(0, \sigma_\varepsilon^2\right),$$

where $Y_{i,T}$ is the value of the indicator in year T, and $Y_{i,0}$ is the value in the initial year. Y_i^* represents the steady-state or equilibrium value of the indicator in each OECD country, and γ is the coefficient to be estimated for detecting convergence. A negative value of γ indicates convergence, while a positive value indicates divergence.

$$\gamma = -\left(1 - e^{-\beta T}\right) \tag{3}$$

The convergence rate or speed (β) can be calculated by using the following equality[7]:

$$\beta = -\frac{ln(1+\gamma)}{T} \tag{4}$$

The estimation of equation (2) by least squares (LS) may be downwardly biased if the covariance between the countries' initial conditions and their steady state is positive, resulting in lower convergence rates. To address this inconsistency, panel data analysis can be employed.

3.3. Beta convergence: panel analysis and recursive estimations

To test the convergence hypothesis using panel data, we again followed the approach proposed by Barro and Sala-i-Martin [81], applied to growth over k periods[8]:

$$y_{it} = \alpha + (u_i + u_t) + \gamma x_{it} + \varepsilon_{it} \tag{5}$$

$$y_{it} = ln\left(\frac{Y_{i,t}}{Y_{i,t-k}}\right)$$

$$x_i = ln\left(Y_{i,t-k}\right) - \frac{1}{N}\sum_{i=1}^{38} ln\left(Y_{i,t-k}\right)$$

$$\varepsilon_{it} \sim N\left(0, \sigma_\varepsilon^2\right)$$

The advantage of panel analysis is that it allows us to control for the specific "steady states" of each country, which remain constant over time, by incorporating the term u_i. This term accounts for all fixed effects within countries, representing, among other factors, the combined influence of institutions, factor endowments, and relative location, along with initial technological differences (hereinafter, the one-way estimator). In the spirit of Barro and Sala-i-Martin [81], allowing for country-specific steady states implies that our panel specification with fixed effects should be interpreted as a conditional beta-convergence framework, rather than a purely unconditional one. Similarly, u_t captures the fixed effects across time units—i.e., those changes over time that are constant across regions or countries, such as the rate of technological change [82]. Controlling for both effects (u_i y u_t) is referred to as the two-way estimator.

The literature indicates that fixed-effects panel analysis typically yields a higher speed of convergence than that obtained in cross-sectional analysis, as it corrects for the positive asymptotic bias that may be present in the latter. Accordingly, GDP per capita convergence rates of 12% to 20% per annum are common—significantly higher than the 2% usually found with cross-sections or panels without fixed effects [81].

Isla-Castillo et al. [51] have empirically demonstrated that convergence rates in European Union regions can be sensitive to economic cycles and extraordinary events such as the COVID-19 pandemic, as well as to possible spatial dependence. Building on this insight, this paper proposes a recursive estimation of equation (4), using GDP per capita and tax burden data for the period 1995–2022, with 1995 set as the initial year and beginning with a growth period of five years (k = 5). The resulting various recursive estimates provide the temporal evolution of the convergence rates of both GDP per capita and the tax burden, and how these may have been influenced by the economic cycle, the 2008 financial crisis, and the COVID-19 pandemic.

3.4. Granger causality analysis

In line with the above, there does not necessarily have to be a strict correlation between the level of economic development and the magnitude of the tax burden. However, given the potential interdependence between the two, we examine whether the respective speeds

[5] See [96] for further details on the measures. The OECD [78] highlights some significant methodological aspects for each of these indicators. A recent application of these one in a panel data context is provided by Garashchuk et al. [97].

[6] To reach the 'steady state' common to all regions, those with a low GDP per capita must grow faster than those with a higher GDP per capita.

[7] For the speed of convergence to be well-defined, the condition $-1 < \gamma < 0$ must be satisfied.

[8] The higher the value of k, the fewer observations are available in the panel.

of convergence may also be related. Accordingly, based on the convergence speeds obtained recursively, the direction of causality between the speeds achieved by the tax burden and economic development during the period 2000–2022 is analysed.

Drawing on the specification of a VAR[9] (vector autoregressive model), a Granger causality analysis is proposed [83], using the following multi-equation specification with two lags[10]:

$$\gamma_t^{tax\_b} = \pi_{10} + \pi_{11}\gamma_{t-1}^{tax\_b} + \pi_{12}\gamma_{t-2}^{tax\_b} + \pi_{13}\gamma_{t-1}^{gdp} + \pi_{14}\gamma_{t-2}^{gdp} + \varepsilon_{1t} \quad (6)$$

$$\gamma_t^{gdp} = \pi_{20} + \pi_{21}\gamma_{t-1}^{tax\_b} + \pi_{22}\gamma_{t-2}^{tax\_b} + \pi_{23}\gamma_{t-1}^{gdp} + \pi_{24}\gamma_{t-2}^{gdp} + \varepsilon_{2t} \quad (7)$$

$\gamma_t^{tax\_b}$ and γ_t^{gdp} represent the convergence coefficients of the tax burden and GDP per capita, respectively, in year *t*.

The null hypothesis that convergence rates in GDP per capita do not influence convergence rates in tax burden is given by:

$$H_0 : \pi_{13} = \pi_{14} = 0 \quad (8)$$

The null hypothesis that convergence rates in tax burden do not influence convergence rates in GDP per capita is expressed as:

$$H_0 : \pi_{21} = \pi_{22} = 0 \quad (9)$$

To test the null hypotheses, the Lagrange Multiplier test or the Wald test based on Snedecor's *F* can be used, as they are asymptotically equivalent [84].

In practice, the choice of the maximum lag length in the unrestricted VAR is guided by standard information criteria (such as the Akaike and Schwarz criteria) and by residual diagnostics. We select the smallest lag order that ensures the absence of residual autocorrelation and yields a stable VAR representation. In our specification used as an example, this leads to a VAR with d = 2 lags for the convergence rates of the tax burden and GDP per capita.

Since standard Granger causality tests require stationary series, we first assess the order of integration of the recursively estimated convergence parameters. When at least one of the series included in the VAR is found to be non-stationary, we follow the procedure proposed by Toda and Yamamoto [85]. Specifically, let d_{max} denote the highest integration order detected among the variables. The VAR in levels is then augmented with d_{max} additional lags, so that the system is estimated with a total lag length:

$$d^* = d + d_{max} \quad (10)$$

Granger causality is subsequently tested by applying Wald restrictions only to the first d lags of the relevant coefficients. This augmented VAR approach ensures the asymptotic validity of the causality tests even in the presence of non-stationary or mixed-order series.

4. Results

4.1. Panel data: descriptive, temporal, and dependency analysis

The OECD [56] reports the evolution of the average tax burden ratios for the member countries of the organization over the period 1965–2022, and notes that in the latter year, for which the data are partial and provisional, tax burden ratios varied considerably across countries.

The GDP per capita (GDP_PC) data panel is expressed in constant 2015 US dollars and was obtained from the World Bank.[11] The tax burden data (TAX_BURDEN) are expressed as percentages (%) and were sourced from the OECD.[12] The final balanced panel comprises 1064 observations, distributed across 38 OECD countries over 28 years (1995–2022).[13] This balanced dataset is used for the descriptive analysis and for assessing sigma-convergence (disparities). We employ the 1990–2022 panel — which is balanced for GDP per capita (1254 observations) but unbalanced for the tax burden with 1219 observations[14]— for the beta-convergence analysis (both cross-country and panel), recursive estimation, and Granger causality tests, to make full use of the available information. It should be noted that the panel estimations capture the average convergence speeds of the countries considered.

Table 1 presents a statistical summary of the panel and the magnitude order. The tax burden reaches a maximum value of 50.3% (Iceland, 2016) and a minimum of 9.9% (Mexico, 1996), with an average of 32.7%. GDP per capita has a maximum of US$140,435.8 (Luxembourg, 2007) and a minimum of US$10,837.8 (Colombia, 1991), with an average of US$45,053.0. The coefficient of variation for GDP per capita stands at 48.3%, which is double the dispersion observed in the tax burden.

For a more effective descriptive analysis, we now consider the time dimension (using average values across countries) to examine the evolutionary or non-stationary nature of the time series [84]. Fig. 2 illustrates the temporal evolution of both variables, which are clearly non-stationary. GDP per capita exhibits a more pronounced growth trend than the tax burden, as the latter is practically constrained by its nature as a ratio. Although there are no formal regulatory limits, in practice the tax burden typically ranges between 15% and 60%. Furthermore, given the different nature of the two variables, GDP per capita shows cumulative growth exceeding 60%, whereas the tax burden barely surpasses 10%. Finally, the graph highlights the negative impact on growth caused by the 2008 financial crisis and the effects of the COVID-19 pandemic.

Taking the cross-sectional units (average values over time) as a reference, Fig. 3 presents a scatter plot illustrating the relationship between GDP per capita and the tax burden, with the dotted lines indicating the average values reported in Table 1. As shown, the graph suggests a positive and non-linear relationship (black line). The linear correlation coefficient is 0.47% and is significant at 1% level. Thirteen countries are identified as having below-average levels of both economic

Table 1
Descriptive statistics of the tax burden and GDP per capita of the OECD-38.

	TAX_BURDEN	GDP_PC
Mean	32.7	45053.0
Median	33.0	43251.6
Maximum	50.3	140435.8
Minimum	9.9	10837.8
Std. Dev.	7.9	21778.8
C.V.	24.1	48.3
Skewness	−0.3	1.4
Kurtosis	2.8	6.7
Observations	1064	1064

Note: (a) Maximum to minimum ratio; (b) coefficient of variation and (c) Gini index.
Source: Own elaboration based on data of World Bank

[9] See Greene [98] and Gujarati (2010) [99].
[10] To determine the optimal number of lags, the AIC (Akaike), SC (Schwarz), and HQ (Hannan-Quinn) information criteria can be used. See Hill et al. [100].
[11] World Bank: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD?end=2015&locations=R.
[12] OCDE: https://data.oecd.org/tax/tax-revenue.htm.
[13] For 2022, the tax burden data for Australia and Japan were estimated based on the overall OECD average.
[14] There are 35 observations missing, distributed across 9 countries: Czechia (3), Estonia (5), Hungary (1), Israel (5), Lithuania (5), Latvia (5), Poland (1), Slovakia (5), and Slovenia (5). However, despite these missing data points, both the between-country and panel estimations provide the average convergence speeds for the 38 OECD countries.

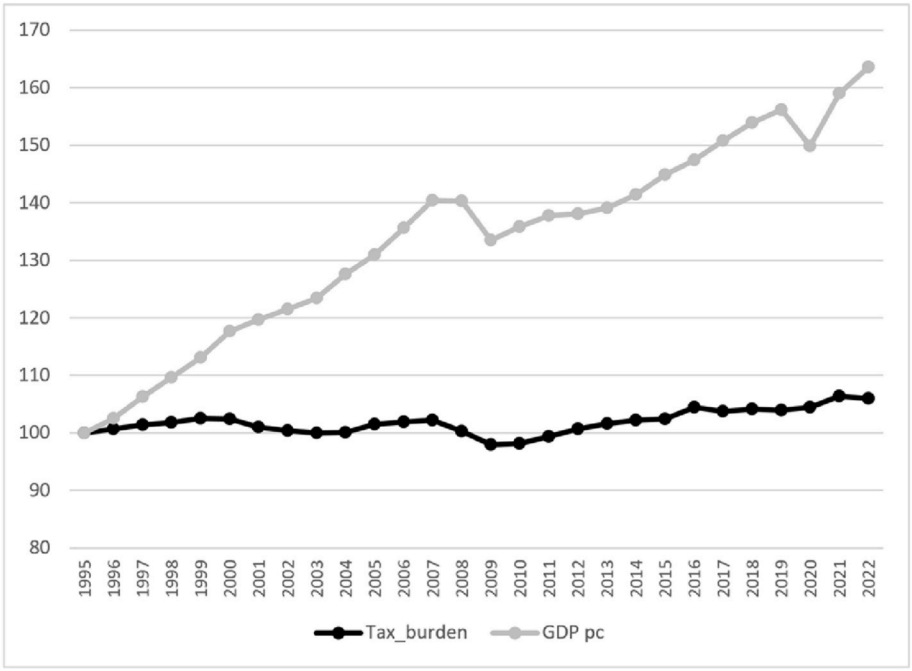

Fig. 2. Temporal evolution of tax burden and GDP per capita in the OECD-38.
Source: Own elaboration based on data of World Bank.

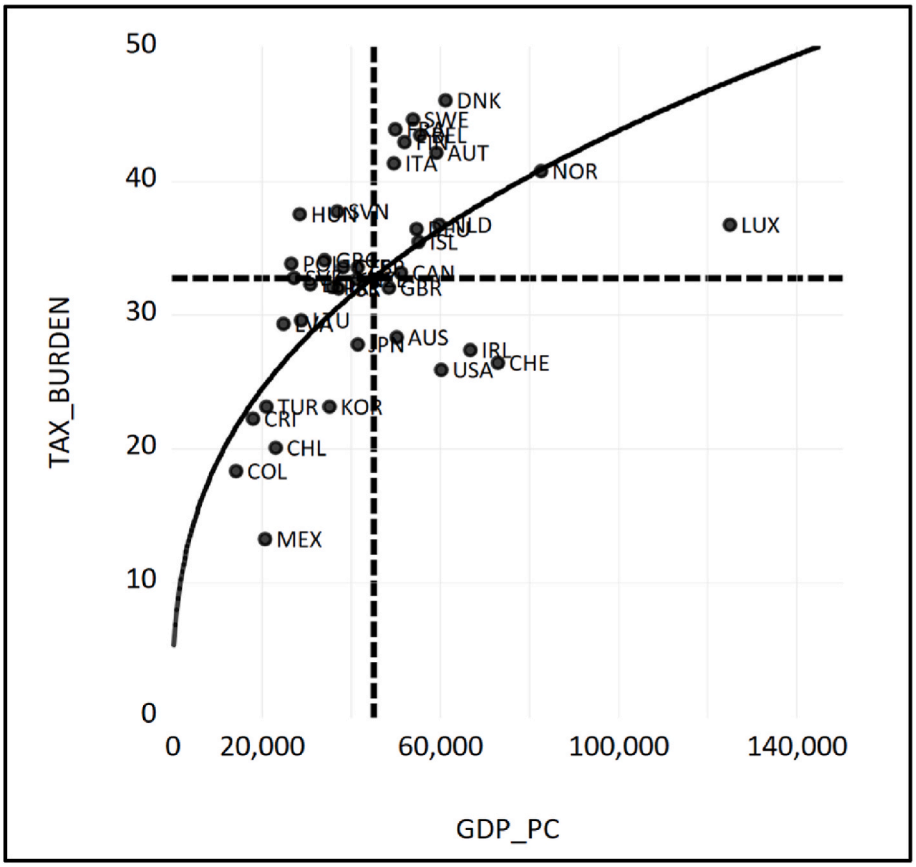

Fig. 3. Panel mean values of tax burden and GDP pc of the OECD-38.
Source: Own elaboration based on data of World Bank.

development and tax burden. Among the least developed, Colombia (COL) and Mexico (MEX) exhibit the lowest tax burdens. At the opposite end of the spectrum, there are also thirteen countries with above-average levels of both development and fiscal pressure. This group

includes, for example, Luxembourg (LUX) and Norway (NOR). Among the countries that do not conform to the established relationship, seven have low levels of development but high fiscal pressure—such as Hungary (HUN)—while five are relatively more developed but display below-average tax burden levels, such as the United States (USA).

4.2. Convergence analysis: tax burden and economic development

Fig. 4 shows the phenomenon of sigma convergence, where we can see how the disparities given by the max/min ratio (MAX_MIN) and the coefficient of variation (CV, expressed in percentage terms), as well as the inequality measured by the Gini index (GINI, also expressed as a percentage), decrease over time. In any case, sigma convergence levels are more favourable in terms of the tax burden.

Fig. 5 and Table 2 analyse the phenomenon of beta convergence, using in this case the panel mean values[15] and the "between" estimator applied to equation (2), with a time lag of 10 years ($k = 10$).[16] Although this estimator is likely to be downward biased due to the positive correlation between initial conditions and countries' steady states, it allows us to obtain an initial comparative view of the convergence achieved by both economic indicators. As shown in Fig. 5, the slopes measuring the speed of convergence are very similar for the tax burden and GDP per capita. Specifically, Table 2 shows that the convergence speeds reach 1.4% in both cases. The dispersion in the scatter plot is also very similar, as evidenced by the coefficients of determination (R^2). In terms of convergence in economic development, two countries stand out. On the one hand, Mexico (MEX), which, starting from a below-average initial situation, has experienced below-average growth. On the other hand, Ireland (IRL), which started from a favourable initial position, has shown above-average growth in economic development. Finally, in the case of the tax burden, Greece (GRC) stands out: starting from an initial situation close to the average, it has experienced very high growth compared to the other countries.[17]

Table 3 presents the results of the panel estimation using the least squares (LS) method, fixed effects by country (one-way), and fixed effects across all units of the panel (two-way), considering, in all cases, a time lag of 10 years ($k = 10$). Under the assumption of a single steady state, the LS estimator yields results superior to those of the "between" estimator, approaching 2% in the case of GDP per capita. When controlling for countries' steady states (one-way), the convergence rates increase to 5.3% for GDP per capita and to 16.8% for the tax burden. If we control for all fixed heterogeneity in the panel (two-way), the convergence speed rises to 8% for GDP per capita and remains around 16% for the tax burden.

Finally, using the recursive estimates of equation (5), Fig. 6 presents the different estimates of γ and the convergence rates for the period 2000–2022, obtained using the three methods: LS, one-way, and two-way. Under the assumption of a single steady state (LS), convergence speeds in both the tax burden and economic development stabilise at around 1.6% from 2014 onwards, remaining at this level until the end of the period. When heterogeneity in the panel is controlled for (one-way and two-way), the influence of economic cycles, the financial crisis, and the pandemic on the evolution of convergence rates becomes evident. Crisis periods tend to increase convergence rates, while the opposite occurs during expansionary phases. This suggests that, in expansionary periods, countries with above-average initial conditions experience greater growth than those starting from below-average positions. Conversely, during recessions—such as the 2008 financial crisis or the pandemic— countries with less favourable or below-average starting positions experience smaller declines in growth.

Table 4 shows the evolution of two sigma-convergence indicators (the max/min ratio and the coefficient of variation) across three periods: 1995–2007, 2008–2013, and 2014–2019. We differentiate between less developed countries (GDP per capita below the sample mean) and more developed economies (above the mean). The table reveals that during the financial-crisis period and the subsequent recovery (2008–2013), dispersion levels declined more sharply than during the pre-pandemic expansionary period (2014–2019). This reduction is particularly pronounced among the less developed countries.

Furthermore, although we acknowledge that β-convergence does not necessarily imply σ-convergence [81,86], the empirical pattern observed in Table 4 is consistent with the conjecture that convergence accelerates during recessionary periods, as countries with initially lower development levels experienced comparatively smaller declines.[18]

As can also be seen in Fig. 6, when heterogeneity is controlled for, the γ parameter becomes much more negative, significantly increasing the convergence speeds—to the point that, in certain periods, it is not defined since $\gamma < -1$.

4.3. Granger causality test

Finally, since fiscal pressure is conditioned by economic development—which, in turn, may depend on tax revenues—this section analyses whether the levels of convergence may also be related, and whether it is possible to establish a causal ordering.

The Granger causality analysis is applied to the time series of the gamma parameter associated with the speed of convergence, for both GDP per capita and the tax burden, covering the period 2000–2022. To obtain these time series, we apply a recursive estimation procedure over the panel dataset (1990–2022). In each recursive window, the gamma coefficient is estimated under three alternative specifications: pooled least squares (LS), cross-section fixed effects, and two-way fixed effects (country and time).

Note that, in order to obtain the gamma estimate for the first year of the time series, namely the year 2000, the first window (1995–2000) is constructed with a lag of $k = 5$, which requires data to be available from 1990 onwards. In the next window (1996–2001), now with a lag of $k = 6$, the gamma estimate for 2001 is obtained, and so on until the full time series is completed.

The Granger causality test is applied to a VAR model with four lags ($d^* = 4$). The number of lags was determined following the Toda–Yamamoto [85] procedure, given that the gamma time series for GDP per capita are non-stationary in two cases (using LS and two-way fixed effects in the recursive panel estimation). Table 5 shows the final lag selection based on the usual criteria (the value of d)[19] and the presence of unit roots (the value of d_{max})[20]. Table 6 summarises the Granger causality tests applied to the different gamma convergence time series under the various estimated panel specifications. The results indicate that, when heterogeneity is not controlled for (LS), no causality is found in either direction. However, when fixed effects are controlled for, the

[15] For the beta-convergence and to make full use of the information available, we employ the 1990–2022 panel.

[16] Barro and Sala-i-Martin [81] warn that using very short periods may bias convergence speeds because they are more affected by cyclical shocks. To avoid this issue, we use herein ten-year growth intervals, which dilutes transitory business-cycle effects and allows us to capture medium- and long-term structural dynamics.

[17] The fiscal consolidation policy implemented in Greece following the debt crisis that emerged towards the end of the first decade of the present century has focused on both expenditure and public revenue. Indeed, in 2025, 'the primary surplus is expected to remain high at 2.5 per cent of GDP' ([97], p. 10). As highlighted by the OECD [82], in Greece, 'Tax revenue has increased from 33.4% of GDP in 2000 to 41% in 2022, above the OECD average'.

[18] β-convergence is a necessary but insufficient condition for a reduction in dispersion, and σ-convergence may arise even in the absence of β-convergence, especially in the presence of asymmetric shocks [101,102].

[19] Annex Table 1 details the criteria used to determine the number of lags.

[20] Annex Table 2 details the criteria used to determine the number of unit roots using the augmented Dickey–Fuller test.

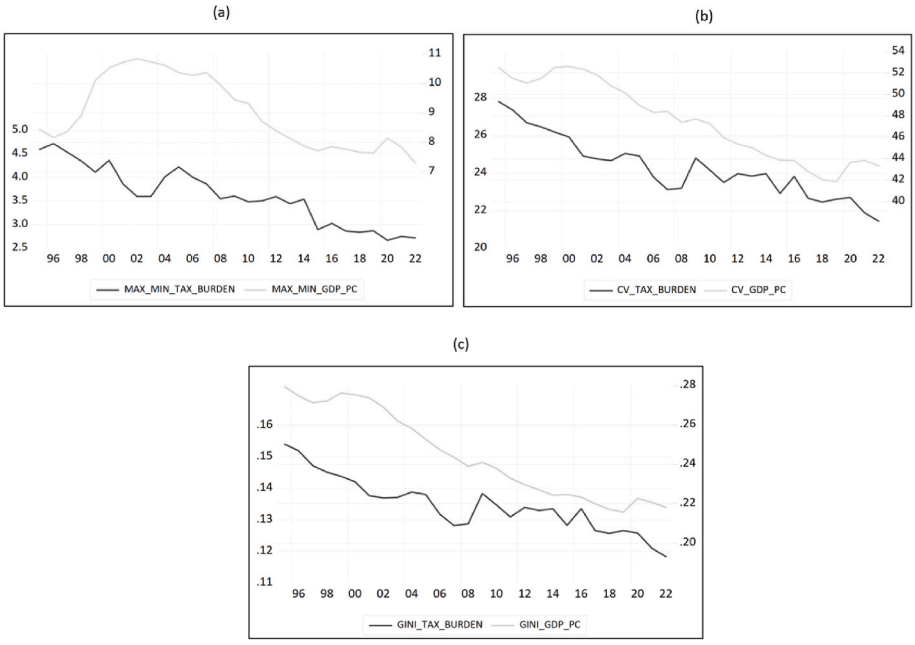

Fig. 4. Measures of tax burden and GDP pc disparities in OCDE-38 countries.
Note: (a) Maximum to minimum ratio; (b) coefficient of variation and (c) Gini index.
Source: Own elaboration based on data of World Bank.

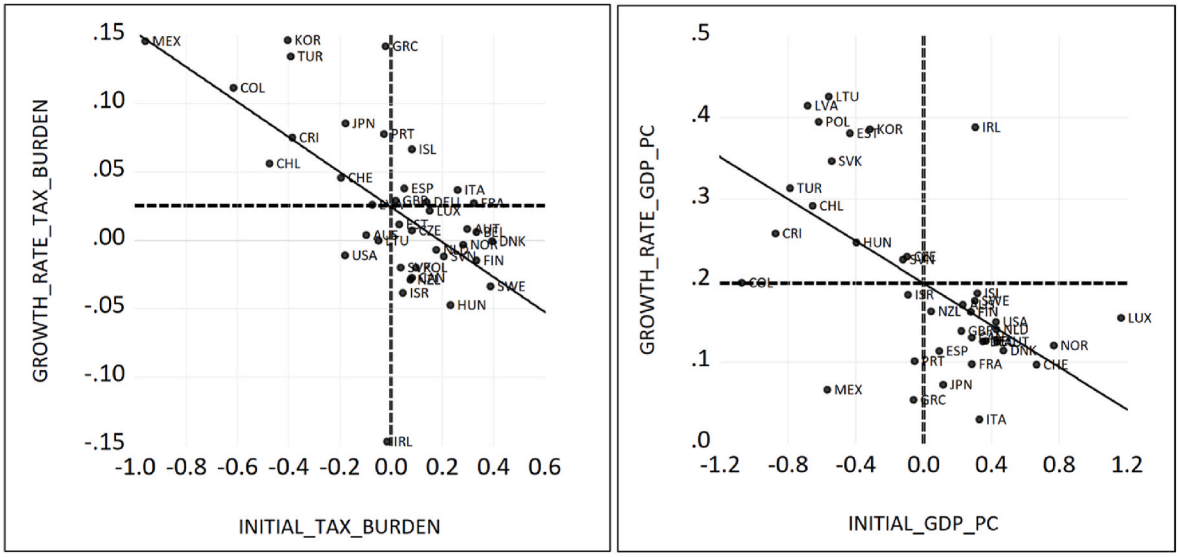

Fig. 5. β-convergence (between estimator).
Source: Own elaboration based on data of World Bank

Table 2
Results of between estimator.

	Tax burden		GDP pc	
Obs	38		38	
R^2	0.38		0.34	
A	0.02	***	0.20	***
Γ	−0.13	***	−0.13	***
Speed (%)	1.37		1.38	

Notes: *,**,*** indicate significance at the 10%, 5% and 1% level, respectively.
Source: Own elaboration based on data of World Bank.

speed of convergence of GDP per capita can be considered a potential cause of the speed of convergence of the tax burden, with a lower level of significance when the full heterogeneity of the panel is taken into account.

The empirical evidence shows that convergence in GDP per capita Granger-causes convergence in the tax burden. This result is consistent with the view that economic convergence tends to align several structural dimensions that directly shape fiscal outcomes, including countries' revenue-raising capacity, the composition and elasticity of tax bases, the social demand for public services, and the institutional features of tax administration. As these structural characteristics become more similar, tax burden levels tend to converge as well. In contrast, fiscal convergence does not necessarily induce convergence in GDP per capita, since relative economic growth depends on broader factors—such as productivity dynamics, technological progress, human capital, and external shocks— that are not determined by the degree of

Table 3
Speed of convergence of the OCDE-38 (1995-2022).

Tax burden	LS		One-way		Two-Way	
A	0.0255	**	0.0255	***	0.0255	***
	(0.0096)		(0.0050)		(0.0020)	
Γ	−0.1595	***	−0.8128	***	−0.8100	***
	(0.0207)		(0.0990)		(0.0324)	
R^2	0.2262		0.6315		0.6902	
speed (%)	1.7		16.8		16.6	

Notes:*,**,*** indicate significance at the 1%, 5% and 10% level, respectively.
Robust standard errors are displayed in parentheses (two-way clusters).

GDP pc	LS		One-way		Two-Way	
A	0.1968	***	0.1968	***	0.1968	***
	(0.0177)		(0.0076)		(0.0028)	
Γ	−0.1625	***	−0.4129	***	−0.5493	***
	(0.0345)		(0.0624)		(0.0312)	
R^2	0.2860		0.6870		0.8123	
speed (%)	1.8		5.3		8.0	

Notes: *, **, and *** indicate significance at the 10%, 5% and 1% level, respectively.
Robust standard errors are displayed in parentheses (two-way clusters).

Source: Own elaboration based on data of World Bank.

similarity in tax systems. Thus, the unidirectional Granger causality observed in our results reflects an economically plausible mechanism in which the process of economic convergence acts as a driver of fiscal convergence.

5. Discussion and conclusions

5.1. Analysis of findings

This paper verifies that there is a clear, non-linear, and positive dependency between the two phenomena using panel data. In terms of convergence, we found that the speed of convergence in the tax burden is similar to that of GDP per capita under a single steady state, both using

Table 4
Sigma convergence: max/min ratio and CV.

	Max/min ratio		CV	
Period	Less	More	Less	More
1995-2007	–	–	–	–
2008-2013	−13.7	0.8	−10.6	−1.9
2014-2019	−3.7	−7.2	−8.4	−6.7

Note: percentage change between the periods considered.

Table 5
Determination of VAR lag lengths (Toda–Yamamoto procedure).

Specification	d	d_{max}	d*
LS (Pooled)	3	1	4
One-way FE	4	0	4
Two-way FE	3	1	4

Notes.
d: optimal VAR lag length.
d_{max}: maximum integration order from ADF tests.
$d^* = d + d_{max}$.

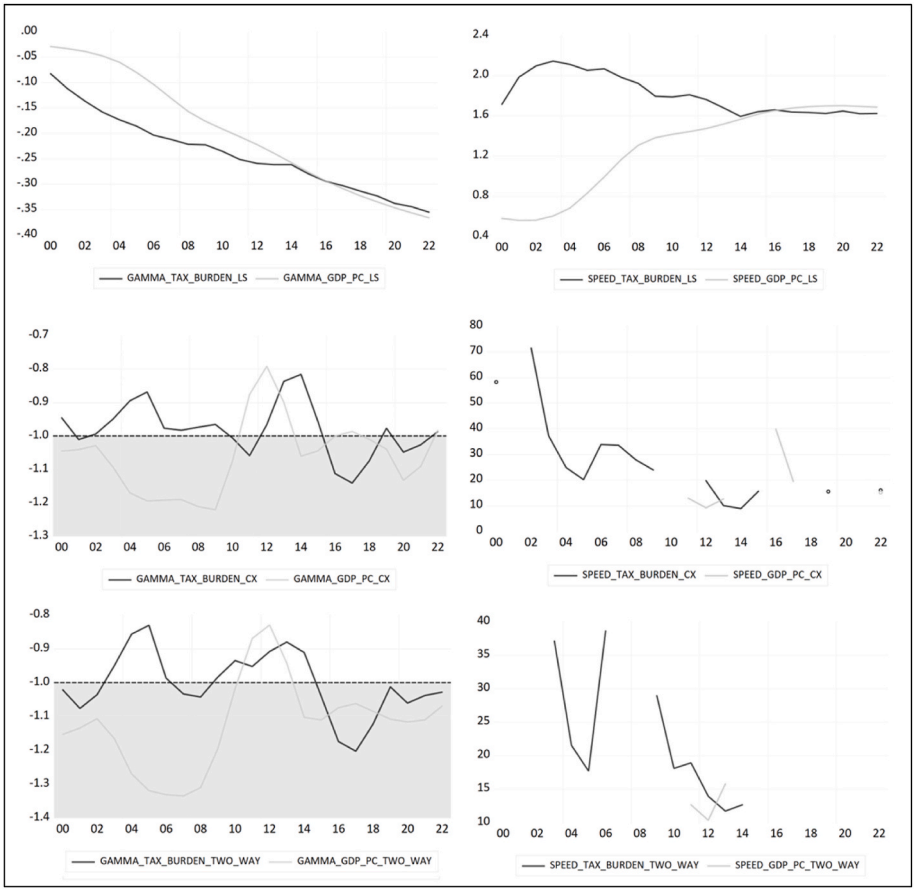

Fig. 6. Gamma and speed of convergence of the OCDE-38 (recursive method).
Source: Own elaboration based on data of World Bank.

Table 6
Granger causality test.

VAR Granger Causality/Block Exogeneity Wald Tests (LS)			
Sample: 2000 2022			
Included observations: 19			
Dependent variable: $\beta_t^{tax\_b}$			
Excluded	Chi-sq	df	Prob.
$\gamma_{t-1}^{gdp}, \gamma_{t-2}^{gdp}, \gamma_{t-3}^{gdp}, \gamma_{t-4}^{gdp}$	0,3695	3	0.9465
Dependent variable: β_t^{gdp}			
Excluded	Chi-sq	df	Prob.
$\gamma_{t-1}^{tax\_b}, \gamma_{t-2}^{tax\_b}, \gamma_{t-3}^{tax\_b}, \gamma_{t-4}^{tax\_b}$	1.2117	3	0.7502
VAR Granger Causality/Block Exogeneity Wald Tests (one-way)			
Sample: 2000 2021			
Included observations: 19			
Dependent variable: $\beta_t^{tax\_b}$			
Excluded	Chi-sq	df	Prob.
$\gamma_{t-1}^{gdp}, \gamma_{t-2}^{gdp}, \gamma_{t-3}^{gdp}, \gamma_{t-4}^{gdp}$	9.5653	4	0.0484
Dependent variable: β_t^{gdp}			
Excluded	Chi-sq	df	Prob.
$\gamma_{t-1}^{tax\_b}, \gamma_{t-2}^{tax\_b}, \gamma_{t-3}^{tax\_b}, \gamma_{t-4}^{tax\_b}$	7.5452	4	0.1097
VAR Granger Causality/Block Exogeneity Wald Tests (two-way)			
Sample: 2000 2021			
Included observations: 19			
Dependent variable: $\beta_t^{tax\_b}$			
Excluded	Chi-sq	df	Prob.
$\gamma_{t-1}^{gdp}, \gamma_{t-2}^{gdp}, \gamma_{t-3}^{gdp}, \gamma_{t-4}^{gdp}$	8.6468	3	0.0344
Dependent variable: β_t^{gdp}			
Excluded	Chi-sq	Df	Prob.
$\gamma_{t-1}^{tax\_b}, \gamma_{t-2}^{tax\_b}, \gamma_{t-3}^{tax\_b}, \gamma_{t-4}^{tax\_b}$	1.2544	3	0.7400

Source: Own elaboration based on data of World Bank.

the "between" estimator and the least squares (LS) estimator in the panel. However, convergence speeds increase when heterogeneity in the panel is accounted for, becoming significantly higher in the case of tax burden.

Likewise, this study confirms that findings already established in the field of economic development—such as the influence of economic cycles on the convergence process—are also present in the case of the tax burden. During recessionary phases, convergence speeds increase, as countries better positioned relative to the average tend to experience sharper declines in growth than those starting from worse initial positions. During expansionary phases, the opposite occurs. We also found that in less developed countries, the reduction of disparities over time (sigma convergence) is even greater during recessionary phases than during expansions. This pattern is present in observed for both economic development and the tax burden. This study has enabled an analysis of the interdependence between convergence in the tax burden and economic development. The application of Granger's causality test shows that the speed of convergence in the tax burden depends on the speed of convergence in GDP per capita, but not vice versa. This implies that greater convergence in economic development leads to lower disparities and greater convergence in tax policies across OECD countries. This finding is consistent with the notion that fiscal structures tend to adjust to the level of economic development: as countries become more similar in terms of income and productive capacity, their tax systems likewise converge, leading to more aligned levels of taxation. Nevertheless, the level of tax burden is also conditioned by other determinants, such as societal preferences regarding the provision of public services and social benefits.

However, an analysis of the long-term evolution of taxation in OECD countries shows that the observed trends toward convergence in overall ratios and structures are not necessarily irreversible. As discussed in the results section (Section 4), a comparison of data for the period 1995–2022 reveals substantially greater dispersion in GDP per capita than in the tax burden. Owing to the different nature of these variables, GDP per capita has grown considerably more than tax burden levels over this period. Nevertheless, both indicators have been adversely affected by events such as the 2008 financial crisis and the Covid-19 pandemic.

As Tanzi [79], p. 3) pointed out, "Until around 2000, tax levels showed a clear and continuous upward trend[21] and by 2007, the previous upward and uniform movement had stopped. The OECD average rose from 24.9% in 1965 to 32.1% in 1995 and 32.9% in 2007; the estimate for 2023 is 33.9%. Although the average figure has remained relatively stable in recent decades, there have been greater fluctuations in the ratios of individual countries." The tax-to-GDP ratio increased in 29 countries over the period 2010-2023 ([87], p. 16).

When interpreting the data, it is important to consider that changes in the tax-to-GDP ratio are driven by the relative movements of nominal tax revenues and nominal GDP, as highlighted by the OECD ([87], p. 16): "From one year to the next, if tax revenues rise by more than GDP (or fall by less than GDP), the tax-to-GDP ratio will increase. Conversely, if tax revenues rise by less than GDP, or fall further, the tax-to-GDP ratio will fall. Therefore, a higher tax-to-GDP ratio does not necessarily mean that the amount of tax revenues has increased in nominal, or even real, terms".

Regarding the evolution of the dispersion of tax burden ratios across OECD countries the OECD ([78], p. 42) notes that, "the dispersion of tax-to-GDP ratios decreased between 1995 and 2016, with a brief interruption in 2009, a period which coincided with the lowest average OECD tax-to-GDP ratio in the period". Dispersion declined both around the OECD average tax-to-GDP ratio (as measured by the standard deviation and coefficient of variation) and around the median (absolute deviation), as well as when country pairs are considered (Gini coefficient), with all these measures showing similar trends over time.

Throughout the period, divergence within the four income groups was highest among countries with the lowest tax-to-GDP ratios, although dispersion in this group narrowed considerably over the period ([78], p. 46). Regarding tax structures, there is a general— though not uniform— trend towards greater similarity ([78], p. 51).

In addition to the points outlined above and the results of this study, and acknowledging that these findings derive from an analysis of global trends, it follows that, in formulating national tax policies, it is necessary to look beyond the headline tax burden figures and to consider the (inter)connections among their determining factors, particularly those related to economic growth.

5.2. Study limitations and future research

The usual indicator of the tax burden, despite its widespread use, presents notable methodological shortcomings and statistical peculiarities that must be considered when interpreting convergence analyses in relation to economic development. As Domínguez [88,89] points out, such limitations can lead to non-homogeneous comparisons between countries or, within the same country, over time. For instance, the increasing use of tax benefits as substitutes for direct expenditure may result in different apparent levels of tax burden, even when comparable public interventions are actually implemented.

In this work we have adopted the concept of tax proposed by the OECD [56], as mentioned earlier.[22]

Although the OECD includes social security contributions as tax

[21] Between 1980 and 2000, only 3 out of 24 developed countries analysed had reduced their tax burden [103].

[22] This is the definition used by the OECD. Nevertheless, strictly speaking, since in practice the principle of economic capacity (ability to pay) prevails, it would be more accurate to state that taxes are coercive economic obligations without any form of direct consideration ([92], pp. 43–45).

revenue, this approach is not without its drawbacks in conceptual terms. To the extent that contributions are deferred wages and that pension systems are based on a contributory criterion, the assumption of non-equivalence is clearly challenged. The OECD ([87], p. 327) partly recognises this, as mentioned above, when it points out that "They [social security contributions] may, however, differ from other taxes in that the receipt of social security benefits depends, in most countries, upon appropriate contributions having been made, although the size of the benefits is not necessarily related to the amount of the contributions".

The tax structure of developed countries is characterised by a high proportion of labour-related revenues. However, it is important to bear in mind that a large share of the tax burden consists of social security contributions, paid by both employees and employers, which have a significant contributory component, as they are linked to the receipt of social benefits. In European Union countries, the classification of tax revenues by economic function shows that more than half (51.2% in 2023) corresponds to taxes (including social security contributions) on labour, slightly more than a quarter (26.9%) to taxes on consumption, and slightly more than a fifth (21.9%) to taxes related to capital ([90], pp. 36-37).

In this regard, the notion of the labour tax wedge is of great importance. According to the OECD ([91], pp. 20-21), the tax wedge is "a measure of the difference between labour costs to the employer and the corresponding net take-home pay of the employee. This indicator is calculated by expressing the sum of personal income tax, employee plus employer SSCs together with any payroll tax, minus benefits, as a percentage of labour costs. Employer SSCs and—in some countries—payroll taxes are added to the gross wage earnings of employees in order to determine a measure of total labour costs".[23]

Similarly, it cannot be ignored that the tax burden is an indicator that condenses complex information into a single figure and therefore does not reflect the roles played by the various factors determining both the absolute and relative levels of taxation. A detailed analysis of the tax system would identify at least the following elements [92]: i) legislation, which may result in a misalignment of economic policy when determining the tax burden; ii) the use of tax incentives as an alternative to direct public spending; iii) the response of economic agents to tax regulations and its subsequent impact on economic activity; iv) the size of the underground economy; v) collection efficiency; vi) tax avoidance; vii) tax fraud; viii) elasticity of the tax system, and ix) the economic cycle. In this regard, it is important to bear in mind the distinction between so-called tax buoyancy and tax elasticity [56]. The former measures changes in observed tax revenues relative to changes in GDP. When observing tax revenues, two effects are taken into account: changes in tax regulations and automatic responses of revenues to changes in GDP. The concept of tax elasticity does not encompass the first of these effects, focusing solely on passive flexibility.

As recognised by the OECD [56], tax elasticity is a better indicator than overall (automatic and discretionary) changes in tax revenue for assessing tax policy and projecting tax revenues. However, its calculation requires more detailed information, which is not readily available: "It is thus a major challenge to analyse tax elasticity across multiple countries over a long period" ([56], p. 37). The challenge becomes even greater when changes in collection efficiency and other factors significantly affect actual tax revenues.

Ultimately, as the IMF ([93], p. 44) has emphasised, "The appropriate overall level of taxation in any country depends on its characteristics –economic (such as its level of development, revenue from other sources), political (including constitutional), and even geographical (revenue can be harder to raise when borders are long and porous). Unsurprisingly, we cannot rely on theory to identify an 'optimal' size of government". For measuring economic development, we use the predominant indicator in the literature on the subject, namely GDP per capita.[24]

Even though the analysis is based on tax burden data recorded by the OECD, any future expansion of the temporal dynamics analysis, should—despite statistical limitations— take into account certain factors underlying the figures reflected in the tax ratios. Accordingly, it would be appropriate to adjust the tax burden data to account for the differing use of tax benefits. Similarly, the importance of non-tax revenues should be considered, along with the impact of the output gap, the underground economy, and tax fraud. Additionally, the orientation of tax policy—approximated through international tax competitiveness indices—would also merit consideration.

Moreover, when calculating measures of dispersion, the effect of outliers must be controlled for. In this context, although such calculations are usually based on unweighted averages, the vast differences in economic size between countries suggest supplementing the analysis with weighted averages.

Finally, an important issue should be noted. Whereas GDP per capita is assumed to be an indicator expected to grow steadily over time, with no predetermined upper limit, this is not the case with the tax burden ratio. In this sense, there is presumably an "ideal" ratio, which, naturally, cannot reach extreme values. Moreover, historically observed peaks are not definitive, as declines have been observed in some periods. In short, the limitations inherent in GDP as an indicator of development are well known, even if they have not displaced it as the dominant economic measure. Among other considerations, the method of accounting for public production in GDP—largely financed by taxes—implies its direct inclusion in GDP and, consequently, in per capita income.

For future work, it would be relevant to include spatial dependence into the convergence analysis and to assess how this may differentially influence the convergence of the tax burden and economic development.

[23] On the other hand, it is useful to distinguish between the average and marginal tax wedges. According to the OECD [23], p. 21, 'The average tax wedge measures that part of total labour costs which is taken in taxes and SSCs net of cash benefits, while the marginal tax wedge measures that part of an increase in total labour costs that is paid in taxes and SSCs less cash benefits.' In 2024, the total average tax wedge reached 34.9% across the OECD [23], p. 23. However, as noted in Domínguez [104], p. 25), if one takes into account: (i) the deductibility of these business costs for corporate tax purposes, and (ii) the economic equivalence of social security contributions, largely as deferred wages—which should at least partially be considered part of the employees' remuneration—the magnitude of the effective tax wedge is substantially reduced.

[24] However, in recent years, there have been important initiatives aimed at finding more appropriate indicators for measuring economic development. See, for example, Stiglitz et al. [105].

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The use of GDP per capita measured in purchasing power parity terms is another avenue worth considering.

CRediT authorship contribution statement

Fernando Isla-Castillo: Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ana Patricia Montes-Caparrós:** Writing – review & editing, Writing – original draft, Validation, Supervision, Investigation, Formal analysis, Conceptualization. **José M. Domínguez-Martínez:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Investigation, Formal analysis, Conceptualization.

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Annex.

Table 1
Determination of the length of the VAR

VAR Lag Order Selection Criteria						
Sample: 2000 2022						
LS						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	82.22	NA	0.00	−8.44	−8.34	−8.43
1	154.26	121.34	0.00	−15.61	−15.31	−15.56
2	167.37	19.31	0.00	−16.56	−16.07	−16.48
3	**175.16**	**9.83**[a]	**0.00**[a]	**−16.96**[a]	**−16.26**[a]	**−16.84**[a]
4	177.83	2.81	0.00	−16.82	−15.93	−16.67
One-way						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	33.90	NA	0.00	−3.36	−3.26	−3.34
1	49.45	26.19	0.00	−4.57	−4.28	−4.52
2	58.56	13.41[a]	0.00	−5.11	−4.61	−5.03
3	66.04	9.45	0.00	−5.48	−4.78[a]	−5.36
4	**71.84**	**6.11**	**0.00**[a]	**−5.66**[a]	**−4.77**	**−5.51**[a]
Two-way						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	26.97	NA	0.00	−2.63	−2.53	−2.61
1	46.60	33.07	0.00	−4.27	−3.98	−4.22
2	62.89	24.01	0.00	−5.57	−5.07	−5.48
3	**74.02**	**14.05**[a]	**0.00**[a]	**−6.31**[a]	**−5.62**[a]	**−6.20**[a]
4	77.21	3.35	0.00	−6.23	−5.34	−6.08

LR: sequential modified LR test statistic (each test at 5% level).
FPE: Final prediction error.
AIC: Akaike information criterion.
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion.
[a] Indicates lag order selected by the criterion.

Table 2
Augmented Dickey–Fuller Tests for Stationarity of Convergence Parameters (γ)

Results by LS			
Variable	**ADF Statistic**	**p-value**	**Conclusion**
γ^{GDP}	−0.505	0.974	Non-stationary
$\Delta\gamma^{GDP}$	−4.212	0.018	Stationary
γ^{Tax_Burden}	−3.528	0.062	Stationary
$\Delta\gamma^{Tax\_Burden}$	−3.376	0.082	Stationary
Results by Cross-section (One-way)			
Variable	**ADF Statistic**	**p-value**	**Conclusion**
γ^{GDP}	−3.931	0.029	Stationary
$\Delta\gamma^{GDP}$	−4.539	0.009	Stationary
γ^{Tax_Burden}	−5.119	0.003	Stationary
$\Delta\gamma^{Tax\_Burden}$	−4.722	0.006	Stationary
Results by Two-way			
Variable	**ADF Statistic**	**p-value**	**Conclusion**
γ^{GDP}	−2.682	0.253	Non-stationary
$\Delta\gamma^{GDP}$	−4.064	0.023	Stationary

(*continued on next page*)

Table 2 (*continued*)

Results by LS			
γ^{Tax_Burden}	−4.501	0.009	Stationary
$\Delta\gamma^{Tax\_Burden}$	−3.672	0.049	Stationary

Notes.
Null Hypothesis: unit root.
Exogenous: Constant, Linear Trend.
Lag Length: Automatic - based on SIC, maxlag = 4.

Data availability

Data will be made available on request.

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