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Fiscal adjustments and TFP dynamics: addressing reverse causality within a heterogeneous panel framework with global shocks

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Abstract

Purpose – The purpose of this study is to provide new insights into the relationship between fiscal policy and total factor productivity (TFP) while accounting for several economic and econometric issues of the phenomenon like non-stationarity, fiscal feedback effects, persistence in productivity, country heterogeneity and unobserved global shocks and local spillovers affecting heterogeneously the countries in the sample.

Design/methodology/approach – The paper is empirical. It builds an Error Correction Model (ECM) specification within a dynamic heterogeneous framework with common correlated effects and models both reverse causality and feedback effects.

Findings – The results of this study highlight some new findings relative to the existing related literature. The outcomes suggest some relevant evidence at both the academic and policy levels: (1) the causal effects going from fiscal deficit/surplus to TFP are heterogeneous across countries; (2) the effects depend on the time horizon considered; (3) the long-run dynamics of TFP are positively impacted by improvements in fiscal budget, but only if the austerity measures do not exert slowdowns in aggregate growth.

Originality/value – The main originality of this study is methodological, with possible extensions to related phenomena. Relative to the existing literature, the gains of this study rely on the way econometric techniques, recently proposed in the literature, are adapted to the economic relationship of interest. The endogeneity due to the existence of reverse causality is modelled without implying relevant performance losses of the models. Moreover, this is the first article that questions whether the effects of fiscal budget on productivity depend on the impact of the former on aggregate output growth, thus emphasising the importance of the quality of fiscal adjustments.

Keywords Common correlated factors, Cross-country heterogeneity, Dynamic panel analysis, Fiscal policy, Total factor productivity

Paper type Research paper

1. Introduction

The past two decades have been characterised by four major global economic disruptions, i.e. the 2007 global financial crisis, the 2011 European sovereign debt crisis, the 2020 Covid-19 pandemic and the 2022 Russian invasion of Ukraine. These events have stimulated, especially in Europe and the US, the debate on the role of economic policy and the real impacts of fiscal austerity/expansion. Although fiscal responses and their effects have been heterogeneous across time and countries (Afonso and Aubyn, 2010; Calderón *et al.*, 2015; Owusu *et al.*, 2023),

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the years following the Covid-19 pandemic have been dominated by massive government interventions to stimulate economic activity and mitigate social inequalities associated with the crises (Rogoff, 2021; Baussola and Carvelli, 2023). Interestingly, while the latest decades have been characterised by a steady increase in global public debt (Kose *et al.*, 2022; Rogoff, 2022; Carvelli, 2023), many countries – mainly advanced – have experienced growth rates of productivity much below the growth rates of aggregate output (Fernald *et al.*, 2023) – despite the rapid spread of digital technologies (Ciaffi *et al.*, 2022; Wang, 2023). Therefore, it appears crucial to further investigate whether and how discretionary fiscal policy affects the long-run dynamics of productivity.

While several related studies have been proposed in recent years, the results are often controversial. In addition, most of them focus on the effects of fiscal budget variations on aggregate output rather than productivity. As we can deduce from a stream of articles, any expansionary effect of fiscal policy on aggregate growth does not necessarily imply improvements in capital accumulation, productivity or vice-versa (e.g. Pereira, 2000; Blanchard and Perotti, 2002). The evidence of productivity enhancements associated with fiscal austerity (e.g. Dar and Amirkhalkhali, 2002; Schoonackers and Heylen, 2011; Everaert *et al.*, 2015; Castro, 2017) contrasts with the findings of detrimental effects of government surpluses (Hernández De Cos and Moral-Benito, 2013; Yang *et al.*, 2015; Bardaka *et al.*, 2021). We cannot rule out that the divergence in the results is to a large extent due to the different econometric approaches and time horizons considered. Moreover, the productivity effects of discretionary fiscal policies might depend on the way governments run budget surplus/deficits – as it likely occurs for aggregate output (see Alesina and Perotti, 1997).

We depart from the existing literature by exploiting recent advances in the macro-panel literature that allow us to simultaneously address the following issues. Firstly, we isolate the causal effects going from fiscal consolidation to total factor productivity (TFP) by modelling reverse causality. Secondly, we build a dynamic heterogeneous empirical framework to account for heterogeneous cross-country effects and unobservable global factors. Thirdly, we allow for unit root processes of both the variables and the unobserved factors, as well as long-run effects and cointegration. Fourthly, our specifications encompass the fiscal feedback effects and the autoregressive behaviour of TFP. Fifthly, we employ the government structural balance as a measure of deficit/surplus in place of the more widely used cyclically adjusted primary balance (CAPB), in order to maximise our sample's dimension – a fundamental aspect for the inference techniques employed in this panel.

Although some of these issues have already been addressed in part of the above-mentioned studies, especially as it concerns the existence of unobserved global factors (e.g. Schoonackers and Heylen, 2011; Everaert *et al.*, 2015), to the best of our knowledge this is the first empirical analysis that models reverse causality and feedback effects while addressing non-stationarity, country heterogeneity, global common shocks and cointegration. As we will see throughout the article, the robustness of the estimates and the performance of the models is assessed with additional empirical exercises related to both the economic and inferential spheres of the phenomenon under analysis.

The rest of the paper is organised as follows. Section 2 discusses the relevance of TFP for economic growth in the long-run; Section 3 describes the data and implements panel unit root and cointegration tests; Section 4 outlines the econometric strategy; Section 5 discusses the baseline results; Section 6 conducts a battery of robustness checks; Section 7 concludes the study.

2. TFP as a driver of long-run economic growth

The purpose of this section is to briefly discuss the existing links between TFP and economic growth, in order to underline the relevance of the phenomenon under analysis for the economies within a long-run perspective. Although, as mentioned before, the trajectories of TFP and aggregate growth do not necessarily move in the same direction, the long-run dynamics of economic growth are likely to depend to a huge extent on the evolution of TFP, thus motivating the relevance for the macroeconomy of additional analyses on TFP. The existing studies, both theoretical and empirical, highlight the importance of TFP for economic growth, especially when looking at the long-run effects. The main growth models which are constructed on an aggregate production function generally suggest that TFP does determine growth paths and cross-country differences in terms of steady-state level of output, regardless of whether TFP enters the model exogenously (Solow, 1957) or endogenously (e.g. Romer, 1990; Mankiw *et al.*, 1992). Consistently, the seminal work of Caselli (2005) confirms that TFP explains the main cross-country differences in terms of output per capita – mainly because of the different capacities of countries to access the worldwide available technology. Other relevant empirical studies support the findings of strong ties between TFP and economic growth (e.g. Krugman, 1997; Hall and Jones, 1999; Baier *et al.*, 2006), either when considering technical progress or variations in technical efficiency – the two basic components of TFP growth (Danquah *et al.*, 2014). Recent empirical evidence suggests that TFP may affect growth both directly and indirectly, through its effects on inputs (Jia *et al.*, 2020). Therefore, the studies on the TFP effects of discretionary fiscal policy could shed light on the transmission channels through which governments may stimulate economic growth and its components.

3. Data and statistical properties

We conduct the panel analysis by employing annual data for 73 countries over the period 1980–2019. Data on TFP and real output per capita are gathered from the PWT database (Feenstra *et al.*, 2015). As it concerns our measure of fiscal adjustment, we use the government structural balance (as a % of potential GDP) of the IMF's World Economic Outlook (Edition of April 2023). Table 1 reports the descriptive statistics for the full sample and the two subsamples represented by the OECD and non-OECD groups. As we will discuss in the course of the article, the bipartition of the sample into OECD and non-OECD follows the existing empirical literature on the determinants of TFP (e.g. Färe *et al.*, 1994; Danquah *et al.*, 2014). It is worth highlighting that,

Table 1.
Summary statistics

Variables	Obs	Mean	Std. Dev	Min	Max
Full sample					
TFP (log)	1716	−0.052	0.103	−0.729	0.212
General gov. structural balance (% of potential GDP)	1716	−2.205	3.218	−19.155	7.763
Output-side real GDP per capita (ppp)	1716	28018.389	16737.134	1976.453	102622.45
OECD					
TFP (log)	673	−0.038	0.082	−0.324	0.212
General gov. structural balance (% of potential GDP)	673	−2.328	3.210	−19.155	5.505
Output-side real GDP per capita (ppp)	673	39687.363	13605.848	11893.271	102622.45
Non-OECD					
TFP (log)	1043	−0.061	0.114	−0.729	0.168
General gov. structural balance (% of potential GDP)	1043	−2.126	3.223	−14.233	7.763
Output-side real GDP per capita (ppp)	1043	20488.937	14035.063	1976.453	82761.758

Source(s): The author's own elaboration

according to the summary statistics, the fiscal deficit in the OECD area is greater compared to the non-OECD group, thus suggesting that the OECD countries' fiscal stances are more frequently characterised by expansionary policies.

Since the time dimension of the panel is large enough, we investigate the stationarity properties of the variable by employing the so-called CIPS panel unit root test developed by Pesaran (2007). Such a test appears to be the most appropriate to accommodate the economic and statistical features of the phenomenon, as it allows for heterogeneous autoregressive parameters and cross-sectional dependence. The outcomes of the CIPS test, reported in Table A2, suggest that the variables are non-stationary in levels and stationary in first differences.

As a further step, we verify whether our variables of interest are cointegrated by implementing the panel cointegration test proposed by Westerlund (2007). Such a testing procedure consists of four versions – which in turn are grouped into *group-mean* and *panel* tests, depending on the alternative hypothesis specified – and allows for heterogeneous effects and correlation of the error within and across the sections. Unlike most of the existing cointegration tests, the Westerlund test is not based on the distribution of the residuals, as it builds on auxiliary conditional ECM equations and investigates the behaviour of the speed of adjustment term. The results, shown in Table A3, are consistent across the four versions of the test and suggest that TFP and fiscal structural balance are cointegrated, irrespective of whether the levels of output enter the cointegrating vector.

4. Econometric strategy

4.1 Endogeneity and heterogeneity

Since the variables are non-stationary in levels, we begin our analysis by specifying a short-run dynamic equation. By denoting with y the logarithm of TFP (in real and power purchasing parity terms) and with x the government structural balance as a percentage of potential GDP, we can construct the following dynamic equation:

$$\Delta y_{it} = \gamma_i \Delta y_{it-1} + \beta_i \Delta x_{it} + \delta_i \Delta x_{it-1} + \alpha_i + \mathrm{e}_{it} \tag{1}$$

where Δ is the first difference operator. We can notice that Equation (1) is a simple ARDL model of order one with the parameters γ, β, δ and α allowed to vary across the units i. Such parameters are distributed around a common mean with country-specific shocks. The ARDL structure is convenient to accommodate both the dynamic behaviour of technology and the fiscal feedback effects [1]. Equation (1) finds theoretical justifications in several relevant papers that highlighted direct or indirect channels through which government activity is associated with TFP or productivity in broad terms (Barro, 1990; Romer, 1990) – mainly due to the way government surplus/deficit affects the current and expected fiscal and financial costs of capital (Elmendorf and Mankiw, 1999; Codogno *et al.*, 2003; Laubach, 2009; Cochrane, 2011), the growth-maximising ratio between public and private capital stock (Aschauer, 2000) and the steady-state level output of the economies (Aizenman *et al.*, 2007).

The main problem when modelling the nexus between fiscal budget and TFP is endogeneity since discretional fiscal policy can be to a relevant extent affected by current and lagged productivity fluctuations (Hernández De Cos and Moral-Benito, 2013). On the theoretical side, the existence of a reverse causal mechanism linking fiscal policy to TFP – and thus to government structural balance – is mostly due to the automatic stabilisers of government expenditure and the countercyclical nature of discretionary fiscal policy (e.g. Taylor, 2000; Andrés and Doménech, 2006; Fontana, 2009; Chen and Guo, 2013). For instance, a recent study proposed by Sanz-Córdoba (2020) provides both theoretical and empirical evidence suggesting that the less (more) productive countries might impose higher (lower) tax rates to achieve a given level of tax revenue. Therefore, the main challenge is the identification of β – regardless of whether it is assumed to be homogeneous or heterogeneous across the countries. For that purpose, we accommodate any reverse causal effects by specifying the following dynamic equation for the government balance:

$$\Delta x_{it} = \psi_i \Delta x_{it-1} + \varkappa_i \Delta y_{it-1} + \eta_i + v_{it} \tag{2}$$

As we can see, Equation (2) follows the same structure as Equation (1), except for the lack of contemporaneous effects going from y to x – which is our identification condition for β. As a further step, we specify a linear nexus between e_{it} and v_{it}:

$$e_{it} = \kappa_i v_{it} + \mu_{it} \tag{3}$$

where μ_{it} is assumed to be an idiosyncratic error term. Since κ_i significantly differs from zero, we can state that there is evidence of a simultaneous bilateral nexus between structural balance and TFP. By substituting Equation (3) and Equation (2) into Equation (1), we obtain the following short-run dynamic heterogeneous model:

$$\Delta y_{it} = \rho_i \Delta y_{it-1} + \beta_i \Delta x_{it} + \varphi_i \Delta x_{it-1} + c_i + \mu_{it} \tag{4}$$

where $\rho_i = \gamma_i - \kappa_i \varkappa_i$, $\varphi_i = \delta_i - \kappa_i \psi_i$ and $c_i = \alpha_i - \kappa_i \eta_i$. Since now the condition $E(\mu_{it}|v_{it}) = E(\mu_{it}|\Delta x_{it}, \Delta x_{it-1}, \Delta y_{it-1}) = 0$ holds by construction, the estimate of β is filtered by the simultaneity between fiscal budget and TFP. However, Equation (4) still generates inconsistent estimates of β due to the existence of cross-sectional dependence. Therefore, we implement further steps in the next section.

4.2 Cointegration and unobserved global factors

In this section, we extend Equation (4) to accommodate the presence of unobserved global factors affecting TFP. The relevant role of unobserved heterogeneity in explaining cross-country TFP differentials arises in Danquah *et al.* (2014), as the latter can be seen as a global process with country-specific absorptive capacity (Parente and Prescott, 2002; De Visscher *et al.*, 2017). Therefore, the presence of common factors within the sample related to productivity and the dynamics of technology introduces a problem of cross-sectional dependence (Schoonackers and Heylen, 2011). If the common effects were not properly modelled, the estimates of the coefficients would likely be biased (Everaert and De Groote, 2016). Thus, we model the following structure of the error term:

$$\mu_{it} = \Gamma_i' \boldsymbol{f}_t + \varepsilon_{it} \tag{5}$$

where $\boldsymbol{f}$ is a set of unobserved common correlated factors whose impacts, given by the factor-loadings Γ, are allowed to vary across the units. The term ε is the unobserved component independent on the covariates. Moreover, the autocovariance conditioned on the common factors is assumed to be null, i.e. $E(\varepsilon_{it}\varepsilon_{st}|\boldsymbol{f}_t) = 0 \ \forall i \neq s$. By following the common correlated effects (CCE) approach outlined in Pesaran (2006) and extended in Chudik and Pesaran (2015) to the dynamic specifications, we proxy the common correlated factors by including in the model the current and lagged cross-sectional averages of the dependent and independent variables. As suggested by Chudik and Pesaran (2015), adding the floor of $\sqrt[3]{T}$ lags of the cross-sectional variables is necessary to address the autocorrelation issue introduced by the presence of the lagged value of the dependent variable on the right-hand side of the equation. Recent results obtained in the econometric literature highlight some further appealing characteristics of the CCE framework for the cases of analyses similar to the one of the present study, as the related estimators are consistent even in the presence of linear dependence between the unobserved heterogeneity and the covariates (Juodis *et al.*, 2021) and their asymptotic normality persists even when the common factors are over-controlled for (Stauskas, 2023).

Since the two variables are I (1), we can reparametrize Equation (4) into a cross-sectionally augmented ECM version to distinguish short-run dynamics from long-run effects, as well as to accommodate common correlated effects and the convergence of the economies towards an equilibrium path:

$$\Delta y_{it} = \rho_i \Delta y_{it-1} + \beta_i \Delta x_{it} + \varphi_i \Delta x_{it-1} + \sum_{l=0}^{\sqrt[3]{T}} \boldsymbol{\zeta}'_{i,l} \Delta \boldsymbol{z}_{it-l} + \xi(y_{it-1} - \theta x_{it-1} - \boldsymbol{\omega}' \boldsymbol{z}_{it-1}) + c_i + \varepsilon_{it} \tag{6}$$

where the vector of the cross-sectional averages is given by $\boldsymbol{z}_t' = (\overline{y_t}, \overline{x_t})'$. The long-run coefficient associated with x is $\lambda = -\theta\xi$. The short- and long-run factor-loadings are contained, respectively, in the vectors $\boldsymbol{\zeta}$, and $\boldsymbol{\phi} = -\boldsymbol{\omega}'\xi$ represents the speed of adjustment to the equilibrium. A further advantage of the ECM specification is that the model allows for the non-stationarity of the unobserved global factors.

The baseline inferential technique employed to estimate Equation (6) is the pooled mean group estimator (PMG) proposed by Pesaran *et al.* (1999) as it allows short-run heterogeneous effects of both the covariates and the common shocks. The PMG estimator imposes cross-country homogeneity of the long-run coefficients and a common equilibrium path. To give a further sense of robustness, we also model heterogeneously the long-run nexus between fiscal adjustments and TFP by employing the MG estimator of Pesaran and Smith (1995). Although PMG normally gains efficiency relative to MG (Arnold *et al.*, 2011), the latter provides consistent estimates as our T is large enough. Moreover, the MG estimator allows for heterogeneous long-run effects of the unobserved global shocks across the economies – an economically relevant aspect.

5. Baseline results

Table 2 shows the estimates of Equation (6). Unlike Model A, Model B controls for the levels of output per capita (whose associated long-run coefficient is χ). For both versions of the model, we report the regressions with no cross-sectional averages and with their lagged values going from zero to the optimal one (which equals three). While, according to the outcomes of the cross-sectional dependence test, for the PMG (MG) estimates in Model A (Model B) one lag of the cross-sectional averages is enough to effectively accommodate the common shocks, for the other sets of regressions three lags are needed.

The impact of improvements in the fiscal budget is positive and significant – provided that GDP per capita is controlled for. The latter condition is crucial as it suggests that the long-run enhancements in productivity following episodes of fiscal consolidation emerge only if the fiscal surplus is run in such a way that long-run aggregate output growth is not negatively affected. In other words, such results emphasise the role of the structure of fiscal adjustments. For instance, if fiscal consolidation is accompanied by a shift of public resources from unproductive to productive expenditure, the marginal productivity of capital would be positively impacted, thus with beneficial effects on the long-run dynamics of TFP. Indeed, such a mechanism is consistent with theoretical and empirical findings which underline a high degree of complementarity between public and private capital (e.g. Aschauer, 1989; Abiad *et al.*, 2016). On the contrary, if fiscal consolidation is run by increasing corporate taxes, it would end up with negative long-run effects on TFP as it obstacles the capacities of the economies to reduce their gap with the global technological frontier – consistently with the arguments proposed by Schoonackers and Heylen (2011) and Everaert *et al.* (2015). The

Table 2.
Baseline estimates

CSA lags	Model A No CSA	Model A 0	Model A 1	Model A 2	Model A 3	Model B No CSA	Model B 0	Model B 1	Model B 2	Model B 3
PMG										
$\widehat{\rho}_i$	0.2323***	0.2186***	0.2041***	0.2064***	0.2002***	0.2253***	0.2067***	0.2100***	0.2075***	0.2181***
	(0.0110)	(0.0129)	(0.0126)	(0.0140)	(0.0194)	(0.0102)	(0.0114)	(0.0136)	(0.0182)	(0.0276)
$\widehat{\beta}_i$	0.0007	0.0005	0.0005	0.0004	0.0005	0.0007	0.0004	0.0006	0.0004	−0.0000
	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0008)	(0.0005)	(0.0005)	(0.0006)	(0.0007)	(0.0009)
$\widehat{\lambda}$	0.0015**	0.0009	0.0008	0.0009	0.0012	0.0019***	0.0016***	0.0015**	0.0016**	0.0017*
	(0.0006)	(0.0007)	(0.0009)	(0.0011)	(0.0016)	(0.0006)	(0.0005)	(0.0007)	(0.0007)	(0.0010)
$\widehat{\chi}$						0.0020***	0.0015**	0.0017**	0.0018**	0.0016*
						(0.0006)	(0.0006)	(0.0008)	(0.0009)	(0.0009)
$\widehat{\xi}$	−0.7765***	−0.7747***	−0.7828***	−0.7598***	−0.7634***	−0.7838***	−0.7822***	−0.7685***	−0.7482***	−0.7155***
	(0.0174)	(0.0156)	(0.0201)	(0.0334)	(0.0450)	(0.0157)	(0.0184)	(0.0253)	(0.0437)	(0.0753)
Obs. [*N*]	1,566 [73]	1,556 [72]	1,442 [68]	1,303 [62]	1,062 [48]	1,510 [68]	1,427 [62]	1,158 [48]	1,080 [46]	885 [37]
RMSE	0.00629	0.00549	0.00539	0.00502	0.00505	0.00609	0.00506	0.00475	0.00458	0.00448
CSD p-value	1.26e-09	0.502	0.431	0.911	0.472	0.00746	0.00531	4.13e-09	7.59e-06	0.980
MG										
$\widehat{\rho}_i$	0.2007***	0.2006***	0.2012***	0.2008***	0.2009***	0.2012***	0.2008***	0.2009***	0.2007***	0.1996***
	(0.0011)	(0.0011)	(0.0011)	(0.0010)	(0.0009)	(0.0011)	(0.0010)	(0.0009)	(0.0009)	(0.0009)
$\widehat{\beta}_i$	0.0010*	0.0009*	0.0012**	0.0010**	0.0011**	0.0012**	0.0010**	0.0011**	0.0010**	0.0004
	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0004)
$\widehat{\lambda}_i$	0.0004	0.0004	0.0004	0.0002	0.0000	0.0024***	0.0024***	0.0027***	0.0025***	0.0025***
	(0.0008)	(0.0006)	(0.0006)	(0.0006)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)
$\widehat{\chi}_i$						0.0027***	0.0025***	0.0025***	0.0024***	0.0017***
						(0.0007)	(0.0006)	(0.0006)	(0.0006)	(0.0005)
$\widehat{\xi}_i$	−0.7993***	−0.7994***	−0.7988***	−0.7992***	−0.7991***	−0.7988***	−0.7992***	−0.7991***	−0.7993***	−0.8004***
	(0.0011)	(0.0011)	(0.0011)	(0.0010)	(0.0009)	(0.0011)	(0.0010)	(0.0009)	(0.0009)	(0.0009)
Obs. [*N*]	1,566 [73]	1,556 [72]	1,442 [68]	1,303 [62]	1,062 [48]	1,510 [68]	1,427 [62]	1,158 [48]	1,080 [46]	885 [37]
RMSE	6.66e-10	6.20e-10	5.79e-10	5.55e-10	5.10e-10	6.11e-10	5.75e-10	5.48e-10	4.96e-10	4.97e-10
CSD p-value	0.00148	0.0322	0.00544	0.0488	0.157	0.724	0.571	0.460	0.925	0.709

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence (CSD) test are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$ is the long-run coefficient associated with GDP per capita
Source(s): The author's own elaboration

effects of short-run variations in the fiscal budget are insignificant in pooled models, whereas some evidence of significant effects emerges in MG estimates. Although the short- and long-run estimated coefficients are slightly higher in the fully heterogeneous models, the results in terms of sign and significance are closely aligned. The speed of adjustment term, ranging from −0.8004 to −0.7155, is significant across all the specifications, suggesting that the economies' adjustment to the (common or country-specific) equilibrium path following a shock in productivity is fast.

It is worth pointing out that the similar long-run estimates between pooled and heterogeneous models do not necessarily imply that the underlying relationship is homogeneous across the countries, as the MG estimates rather reflect an average effect without ruling out the presence of a relevant share of observations that behaves much different from the mass of the distribution. Therefore, as a general rule, it appears convenient to estimate, in addition to pooled models, fully heterogeneous regressions since the TFP levels and dynamics are profoundly different across the economies – even when considering subsets of countries that share similar structural characteristics – although allowing for long-run heterogeneity represents a cost in terms of efficiency (Arnold *et al.*, 2011).

6. Robustness checks

Although in the previous section we evaluate the robustness of the estimates of Equation (6) by considering several methodological alternatives, as well as by assessing the behaviour of the model when a key additional control – the output per capita – is controlled for, in this section we aim at further testing the robustness of the estimates by including additional sets of controls. In addition, we conduct additional empirical exercises in order to address different economic aspects of the phenomenon under analysis, given the availability of our data of interest. Therefore, we proceed as follows.

Firstly, we estimate the models for the full sample by adding as an additional control the international openness index – defined as the sum of imports and exports over GDP (Table A5). Such a choice is due to the relevance of international trade and competition for the dynamics of TFP, especially within a long-run perspective. Moreover, we report in Table A6 the estimates for the entire sample when the full set of controls is considered – i.e. when we control for the demographic trajectories and the financial environment, proxied by the population share of the labour force and the inflation rate, respectively. Such controls are carefully chosen following the existing empirical literature (e.g. Grossman and Helpman, 1993; Beaudry and Green, 2002; Acemoglu, 2010; Danquah *et al.*, 2014) and accounting for the availability of data. The latter aspect is particularly relevant and represents the main constraint in our case since the empirical setup proposed in this study requires sufficiently large N and T for the model to perform well. Indeed, it appears worth recalling that the model – especially when considering an unbalanced panel – loses a relevant number of observations as the number of lags of the cross-sectional averages increases.

Secondly, we make a bipartition of the sample into OECD and non-OECD countries (Table A6 and Table A7), in order to assess whether and to which extent the relationship differs across the two groups [2]. Although the estimates for the full sample suggest that the relationship under analysis is significantly heterogeneous across the countries, grouping the units into two main categories could provide useful economic insights (see, for instance, Färe *et al.* (1994)). Danquah *et al.* (2014) highlight that the determinants of TFP differ between OECD and non-OECD groups. Consistently, we chose the additional controls for the two groups according to the results proposed by Danquah *et al.* (2014).

Thirdly, since the period 1980–2019 was characterised by several social, political and economic shocks, we split the time interval by considering, separately, the 2007 global financial crisis (Table A8 and Table A9) and the 2011 European sovereign debt crisis

(Table A10 and Table A11). Using 2007 and 2011 as time thresholds appears to be an acceptable compromise between the detail degree of the subperiods considered and the need to maintain a large enough time dimension to consistently estimate the coefficients – especially when assuming long-run slope heterogeneity. Moreover, the two events considered represent the most relevant economic disruptions over the time horizon employed in this study. Since the bipartition of the time dimension implies a substantial restriction of the time spans, we consider as the control variable only the output per capita in order to avoid further losses of observations and reductions in the cross-sectional dimension. Furthermore, considering that the time-splitting process drastically reduces the temporal dimension and the total number of observations, especially when considering the regressions post 2008 and 2011, we do not report the estimates for some of the specifications that require a positive number of lags of the cross-sectional averages in order to maintain a sufficient large dimension of N and T.

The overall results for the whole sample closely align with their baseline counterparts, except for a slighter magnitude long-run effect of budget surpluses, with no relevant differences when the long-run nexus between fiscal budget and TFP is modelled heterogeneously. No diverging conclusions arise even when splitting the time interval. As it concerns the distinction between OECD and non-OECD groups, we can notice some relevant differences. Unlike for the OECD countries, the significance of the estimates associated with the non-OECD economies appears to be slightly different compared to the full sample regressions. Indeed, while within the OECD area fiscal consolidation stimulates TFP in the long-run, if the fiscal adjustment is not contractionary for the aggregate output, such evidence is weaker for the non-OECD subsample. In fact, as all the controls are included in the model, the significant effect of government structural balance disappears for non-OECD economies. This might be to a relevant extent due to the higher marginal product to capital and expected growth rates when the economies' output levels are relatively far from their steady-state levels, thus compensating on average any detrimental long-run effect of deficit-financed unproductive expenditure on TFP. However, it is worth stressing that cross-country heterogeneity is significant even within the OECD and non-OECD groups, thus suggesting parsimony when proposing general policy recommendations.

7. Concluding remarks

The economic and financial global shocks that occurred over the past two decades have pushed governments, mainly in advanced economies, to stimulate growth and contrast social disruptions by massively resorting to deficit-financed expenditures, thus raising serious concerns about the sustainability of public finances in a long-term perspective. At the same time, the growth of productivity is weak or even negative in several countries, likely triggering the existing slowdowns in aggregate output growth. Since the empirical literature provides evidence of significant links between fiscal policy and productivity, it seems to be useful for both academics and policymakers to further investigate additional features of the phenomenon.

This article contributes to the literature on the nexus between fiscal policy and productivity by estimating the effects of fiscal adjustments on TFP while accounting for endogeneity, non-stationarity, country heterogeneity, fiscal feedback effects and global unobserved factors. The overall results suggest that improvements in fiscal structural balance stimulate the long-run dynamics of TFP if the government surplus does not exert downturns in aggregate output. Therefore, the productivity effects of fiscal consolidations are likely to depend on the way policymakers combine variations in expenditure and taxation – similar to what is suggested in Alesina and Perotti (1997) for the effects of fiscal adjustments on aggregate output. Consistently with the arguments provided in

Schoonackers and Heylen (2011) and Banerjee and Zampolli (2019), it appears reasonable to state that any fiscal adjustment that improves the efficiency of public resource allocation ends up with beneficial effects for the TFP's long-run dynamics through improvements in the economies' access to the worldwide available technology. Conversely, running fiscal surpluses by cutting productive expenditure and/or by increasing the fiscal burden on firms through distortive taxation may offset the positive effects exerted by more sustainable fiscal stances, and could imply a reduction in public and private capital accumulation (Calderón *et al.*, 2015; Bardaka *et al.*, 2021; Baussola and Carvelli, 2023), with detrimental effects on the long-run dynamics of TFP. However, it is worth pointing out that while the findings for the full sample are broadly confirmed for the OECD subsample, neutral long-run effects of fiscal structural balance arise when the sample is restricted to the non-OECD countries – thus suggesting that the transmission channels linking fiscal policy to productivity could be different for the two groups. In fact, the differences in terms of TFP dynamics and determinants between OECD and non-OECD countries were already discussed by Färe *et al.*, (1994) and Danquah *et al.* (2014) and are likely due, to a large extent, to the different social, political and economic environments – although we find evidence of cross-country heterogeneity even within the non-OECD group.

Considering the results that arose in the existing literature and this study, we believe that further research should investigate how the single components of government expenditure and revenues, as well as their combinations, affect the dynamics of TFP and how any significant effect evolves from the short-to the long-run. Moreover, employing the government budget constraint (GBC) in the model might provide useful insights and disentangle whether and how the effects on productivity exerted by fiscal expansion (austerity) depend on the goods and services financed (cut) and/or by the reduction (raise) in specific categories of tax and non-tax revenues.

Notes

1. See Ramey (2011) and Abiad *et al.* (2016) for the relevance of lagged fiscal effects.
2. In this study, we categorise as OECD member the countries that entered the group by 1980 – that is the first year of the time span considered in the analysis. Such a choice is due to the willingness to avoid massive observation losses in the MG estimates, which would result by allowing the units to switch from one group to another over the period considered.

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Appendix

OECD	Non-OECD	
Australia	Angola	Lithuania
Austria	Argentina	Malaysia
Belgium	Brazil	Malta
Canada	Bulgaria	Mauritius
Denmark	Chile	Mexico
Finland	China	Morocco
France	China, Hong Kong SAR	Panama
Germany	Colombia	Paraguay
Greece	Costa Rica	Peru
Iceland	Croatia	Philippines
Ireland	Cyprus	Poland
Italy	Czech Republic	Republic of Korea
Japan	Dominican Republic	Romania
Luxembourg	Ecuador	Russian Federation
Netherlands	Egypt	Serbia
New Zealand	Estonia	Singapore
Norway	Guatemala	Slovakia
Portugal	Hungary	Slovenia
Spain	India	South Africa
Sweden	Indonesia	Switzerland
Turkey	Israel	Taiwan
United Kingdom	Jordan	Thailand
USA	Kazakhstan	Tunisia
	Kyrgyzstan	Ukraine
	Latvia	Uruguay

Source(s): The author's own elaboration

Table A1. List of countries

	Levels			First differences		
Lags	1	2	3	1	2	3
Without trend						
TFP	−1.142	−1.468	−1.311	−4.962***	−4.962***	−5.002***
Gov. struc. bal	−2.229*	−2.091	−2.129	−5.875***	−5.875***	−5.668***
With trend						
TFP	−1.645	−2.060	−2.060	−5.415***	−5.415***	−5.500***
Gov. struc. bal	−2.484	−2.301	−2.895**	−6.066***	−6.066***	−5.822***

Note(s): The CIPS test verifies the null hypothesis of non-stationarity. The optimal lag length is selected according to the Akaike information criterion. The linear time-trend term is included in the equations
Source(s): The author's own elaboration

Table A2. CIPS panel unit root test

	Without trend			With trend		
Lags	1	2	3	1	2	3
Without GDP						
Panel statistics						
P_τ	−3.152*	−4.001***	−4.994***	−1.519	−3.745**	−5.090***
P_α	−6.000***	−5.283***	−7.031***	−2.313	−5.544***	−4.965***
Group-mean statistics						
G_τ	−2.099	−4.298***	−6.902***	−3.509**	−3.511**	−3.719**
G_α	−1.012	−5.722***	−5.722***	−2.171**	−4.699***	−5.700***
With GDP						
Panel statistics						
P_τ	−1.320	−3.989***	−4.573***	−1.414	−3.401**	−3.616**
P_α	−1.031	−2.520*	−2.909*	−1.555	−3.806***	−4.010***
Group-mean statistics						
G_τ	−3.540**	−3.212**	−3.688**	−3.313**	−3.981***	−5.019***
G_α	−1.031	−5.430***	−5.492***	−1.356	−5.008***	−5.493***

Note(s): The test verifies the null hypothesis of no cointegration. The test statistics P_α and G_α are obtained through the semiparametric Kernel estimation of the autoregressive coefficient of the conditional ECM equation. The autoregressive coefficients for the test statistics P_τ and G_τ are estimated conventionally. The critical values are obtained through a bootstrap procedure with 500 replications. The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively
Source(s): The author's own elaboration

Table A3.
Westerlund test for cointegration

Table A4. Estimates with GDP and international openness as additional controls, full sample

	PMG					MG				
CSA lags	No CSA	0	1	2	3	No CSA	0	1	2	3
$\widehat{\rho}_i$	0.2289***	0.2178***	0.2118***	0.1936***	0.1612***	0.2010***	0.2002***	0.1989***	0.2007***	0.2013***
	(0.0187)	(0.0181)	(0.0213)	(0.0215)	(0.0350)	(0.0009)	(0.0009)	(0.0012)	(0.0011)	(0.0011)
$\widehat{\beta}_i$	0.0008	0.0004	−0.0002	0.0009	0.0010	0.0010*	0.0008	0.0010*	0.0008*	0.0004
	(0.0006)	(0.0006)	(0.0012)	(0.0010)	(0.0011)	(0.0006)	(0.0006)	(0.0006)	(0.0004)	(0.0008)
$\widehat{\lambda}$	0.0007***	0.0006***	0.0008***	0.0009***	0.0011***	0.0011**	0.0008*	0.0012***	0.0010*	0.0013**
	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0005)	(0.0004)	(0.0002)	(0.0006)	(0.0005)
$\widehat{\chi}$	0.0021***	0.0016**	0.0011	0.0027***	0.0034***	0.0026***	0.0021***	0.0013*	0.0024***	0.0027***
	(0.0007)	(0.0007)	(0.0015)	(0.0010)	(0.0011)	(0.0006)	(0.0005)	(0.0008)	(0.0007)	(0.0007)
$\widehat{\tau}$	0.0023	0.0005	0.0035	0.0160	0.0273	0.0031**	0.0010	0.0061	0.0060	0.0009
	(0.0061)	(0.0071)	(0.0173)	(0.0110)	(0.0176)	(0.0015)	(0.0018)	(0.0049)	(0.0037)	(0.0026)
$\widehat{\xi}$	−0.7611***	−0.7566***	−0.7527***	−0.7895***	−0.8280***	−0.7990***	−0.7998***	−0.8011***	−0.7993***	−0.7987***
	(0.0228)	(0.0283)	(0.0423)	(0.0201)	(0.0359)	(0.0009)	(0.0009)	(0.0012)	(0.0011)	(0.0011)
Obs. [N]	1,170 [47]	1,060 [41]	642 [22]	486 [16]	374 [12]	1,170 [47]	1,060 [41]	642 [22]	486 [16]	374 [12]
RMSE	0.00541	0.00434	0.00461	0.00341	0.00297	5.51e-10	5.18e-10	4.84e-10	4.59e-10	5.10e-10
CSD p-value	0.000	0.000	0.000	0.364	0.350	0.238	0.430	0.710	0.0572	0.811

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$ and $\widehat{\tau}$ are the long-run coefficients associated with GDP per capita and openness index, respectively

Source(s): The author's own elaboration

Table A5.
Estimates with the full set of controls, full sample

	PMG					MG				
CSA lags	No CSA	0	1	2	3	No CSA	0	1	2	3
$\widehat{\rho}_i$	0.2106***	0.1978***	0.1683***	0.1610***	0.1683***	0.1987***	0.1987***	0.1998***	0.1971***	0.1996***
	(0.0214)	(0.0238)	(0.0089)	(0.0098)	(0.0127)	(0.0012)	(0.0012)	(0.0010)	(0.0022)	(0.0008)
$\widehat{\beta}_i$	−0.0000	0.0000	0.0002	0.0000	0.0002	−0.0000	−0.0000	0.0005	0.0002	0.0004
	(0.0007)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0005)	(0.0004)	(0.0004)
$\widehat{\lambda}$	0.0011	0.0011*	0.0012**	0.0011	0.0014**	0.0012	0.0012	0.0019***	0.0013**	0.0017***
	(0.0008)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0005)	(0.0005)
$\widehat{\chi}$	0.0011	0.0016**	0.0026***	0.0031***	0.0028***	0.0015**	0.0013**	0.0017**	0.0017**	0.0019**
	(0.0007)	(0.0006)	(0.0009)	(0.0009)	(0.0008)	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0007)
$\widehat{\tau}$	0.0066	0.0004	0.0103**	0.0204*	0.0042	0.0084	0.0179	0.0239	0.0172	0.0308**
	(0.0061)	(0.0051)	(0.0043)	(0.0108)	(0.0051)	(0.0069)	(0.0143)	(0.0309)	(0.0473)	(0.0122)
$\widehat{\boldsymbol{\Phi}}$	0.0128	0.0175	0.0102	0.0128***	0.0191*	0.0092	0.0243**	0.0122**	0.0092	0.0258***
	(0.0143)	(0.0116)	(0.0354)	(0.0043)	(0.0100)	(0.0320)	(0.0094)	(0.0051)	(0.0320)	(0.0091)
$\widehat{\boldsymbol{\pi}}$	0.0087	−0.0050	−0.0119	−0.0119	−0.0157	−0.0037	−0.0074	−0.0087	−0.0071	−0.0349
	(0.0239)	(0.0151)	(0.0231)	(0.0087)	(0.0185)	(0.0072)	(0.0101)	(0.0133)	(0.0143)	(0.0232)
$\widehat{\xi}$	−0.7807***	−0.8073***	−0.8436***	−0.8509***	−0.8474***	−0.8013***	−0.8013***	−0.8002***	−0.7912***	−0.8004***
	(0.0319)	(0.0244)	(0.0284)	(0.0106)	(0.0293)	(0.0012)	(0.0012)	(0.0010)	(0.0097)	(0.0008)
Obs. [N]	961 [39]	961 [39]	885 [36]	821 [34]	698 [28]	961 [39]	961 [39]	885 [36]	821 [34]	698 [28]
RMSE	0.00438	0.00350	0.00315	0.00290	0.00268	5.85e-10	5.47e-10	4.72e-10	4.43e-10	4.20e-10
CSD p-value	4.85e-06	0.271	0.683	0.480	0.282	0.00295	0.0278	0.00725	0.543	0.119

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$, $\widehat{\tau}$, $\widehat{\boldsymbol{\Phi}}$, and $\widehat{\boldsymbol{\pi}}$ are the long-run coefficients associated with GDP per capita, openness index, labour force and inflation rate, respectively
Source(s): The author's own elaboration

Table A6. Estimates, OECD vs non-OECD. PMG

CSA lags	No CSA	3	No CSA	3	No CSA	CSA	No CSA	3
OECD								
$\widehat{\rho}_i$	0.2079***	0.2083***	0.2118***	0.2000***	0.1852***	0.2241***	0.2013***	0.2013***
	(0.0046)	(0.0394)	(0.0068)	(0.0516)	(0.0107)	(0.0153)	(0.0089)	(0.0089)
$\widehat{\beta}_i$	0.0008	0.0007	0.0008	0.0003	0.0006	0.0007	0.0009	0.0009
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0008)	(0.0007)	(0.0007)	(0.0007)
$\widehat{\lambda}$	0.0024	0.0126	0.0027**	0.0023**	0.0022***	0.0171	0.0024***	0.0024***
	(0.0199)	(0.0114)	(0.0013)	(0.0010)	(0.0008)	(0.0173)	(0.0006)	(0.0006)
$\widehat{\chi}$			0.0027**	0.0014**			0.0031**	0.0027***
			(0.0012)	(0.0007)			(0.0013)	(0.0006)
$\widehat{\tau}$					0.0063	0.0101**	0.0142**	0.0170**
					(0.0047)	(0.0041)	(0.0057)	(0.0075)
$\widehat{\boldsymbol{\Phi}}$					0.0028	0.0000	0.0074	0.0249
					(0.0097)	(0.0066)	(0.0101)	(0.0186)
$\widehat{\boldsymbol{\pi}}$					0.0168**	0.0088	0.0052	0.0080
					(0.0075)	(0.0065)	(0.0139)	(0.0186)
$\widehat{\xi}$	−0.7886***	−0.8367***	−0.7841***	−0.8499***	−0.7977***	−0.8241***	−0.7963***	−0.8080***
	(0.0124)	(0.0225)	(0.0149)	(0.0376)	(0.0246)	(0.0440)	(0.0074)	(0.0061)
Obs. [N]	464 [17]	413 [17]	464 [17]	384[15]	430 [17]	415 [16]	384 [15]	276 [10]
RMSE	0.00341	0.00225	0.00340	0.00170	0.00341	0.00271	0.00233	0.00139
CSD p-value	0.000	0.0778	0.000	0.792	1.85e-06	0.556	0.673	0.688
Non-OECD								
$\widehat{\rho}_i$	0.2370***	0.2017***	0.2320***	0.1729***	0.2265***	0.2069***	0.2094***	0.2051***
	(0.0128)	(0.0222)	(0.0173)	(0.0416)	(0.0122)	(0.0160)	(0.0229)	(0.0246)

(*continued*)

Table A6.

CSA lags	No CSA	3	No CSA	3	No CSA	CSA	No CSA	3
$\widehat{\beta}_i$	0.0007	0.0002	0.0004	0.0002	0.0007	0.0004	0.0003	−0.0004
	(0.0006)	(0.0008)	(0.0006)	(0.0010)	(0.0006)	(0.0007)	(0.0008)	(0.0012)
$\widehat{\lambda}$	0.0014	0.0011	0.0016**	0.0013**	0.0014**	0.0014*	0.0013	0.0008
	(0.0009)	(0.0009)	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0012)	(0.0012)
$\widehat{\chi}$			0.0015**	0.0007			0.0017**	0.0015*
			(0.0006)	(0.0015)			(0.0007)	(0.0008)
$\widehat{\varrho}$					−0.4484**	0.0236	0.2241	0.1532
					(0.2273)	(0.2265)	(0.2655)	(0.3225)
$\widehat{\pi}$					0.0001	−0.0001	−0.0002	0.0004
					(0.0002)	(0.0002)	(0.0004)	(0.0003)
$\widehat{\xi}$	−0.7756***	−0.7479***	−0.7777***	−0.7663***	−0.7852***	−0.7742***	−0.7606***	−0.7076***
	(0.0187)	(0.0437)	(0.0267)	(0.0872)	(0.0174)	(0.0245)	(0.0327)	(0.0859)
Obs. [*N*]	1,248 [56]	1,029 [51]	1,248 [56]	707 [30]	1,080 [51]	384 [14]	1,079 [51]	376 [14]
RMSE	0.00749	0.00591	0.00735	0.00509	0.00685	0.00580	0.00514	0.00549
CSD *p*-value	0.00111	0.561	0.061	0.624	0.0499	0.960	0.599	0.492

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The *p*-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$, $\widehat{\tau}$, $\widehat{\Phi}$, $\widehat{\varrho}$ and $\widehat{\pi}$ are the long-run coefficients associated with GDP per capita, openness index, labour force, population growth and inflation rate, respectively
Source(s): The author's own elaboration

Table A7. Estimates, OECD vs non-OECD. MG

CSA lags	No CSA	3	No CSA	3	No CSA	CSA	No CSA	3
OECD								
$\widehat{\rho}_i$	0.1996***	0.2000***	0.1996***	0.2000***	0.1996***	0.1999***	0.2000***	0.1988***
	(0.0011)	(0.0012)	(0.0011)	(0.0012)	(0.0011)	(0.0011)	(0.0012)	(0.0011)
$\widehat{\beta}_i$	0.0005	0.0006	0.0005	0.0006	0.0005	0.0006	0.0006	0.0009***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0000)
$\widehat{\lambda}$	−0.0142	−0.0058	0.0017**	0.0019**	0.0010	0.0011	0.0028**	0.0023**
	(0.0286)	(0.0207)	(0.0007)	(0.0008)	(0.0011)	(0.0012)	(0.0013)	(0.0010)
$\widehat{\chi}$			0.0017**	0.0019**			0.0017**	0.0019**
			(0.0007)	(0.0008)			(0.0007)	(0.0007)
$\widehat{\tau}$					0.0099***	0.0096*	0.0104	0.0080
					(0.0028)	(0.0057)	(0.0080)	(0.0151)
$\widehat{\boldsymbol{\Phi}}$					0.0262	0.0126	0.0283	0.0194
					(0.0393)	(0.0274)	(0.0308)	(0.0466)
$\widehat{\pi}$					0.0001***	−0.0000	0.0000	0.0002
					(0.0000)	(0.0000)	(0.0001)	(0.0002)
$\widehat{\xi}$	−0.8004***	−0.8004***	−0.8004***	−0.8000***	−0.8004***	−0.8001***	−0.8000***	−0.8012***
	(0.0011)	(0.0011)	(0.0011)	(0.0012)	(0.0011)	(0.0011)	(0.0012)	(0.0011)
Obs. [*N*]	464 [17]	430 [17]	464 [17]	384 [15]	430 [17]	415 [16]	384 [15]	276 [10]
RMSE	5.45e-10	5.20e-10	4.88e-10	3.46e-10	4.61e-10	4.24e-10	3.63e-10	3.57e-10
CSD *p*-value	0.910	0.106	0.00374	0.934	0.545	0.623	0.755	0.0826
Non-OECD								
$\widehat{\rho}_i$	0.2298***	0.1943***	0.2267***	0.2092***	0.2017***	0.2011***	0.2013***	0.1990***
	(0.0166)	(0.0320)	(0.0159)	(0.0164)	(0.0014)	(0.0013)	(0.0013)	(0.0018)

(*continued*)

Table A7.

CSA lags	No CSA	3	No CSA	3	No CSA	CSA	No CSA	3
$\widehat{\beta}_i$	0.0005	0.0003	0.0011	0.0013**	0.0015**	0.0012*	0.0013**	0.0001
	(0.0006)	(0.0007)	(0.0007)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0009)
$\widehat{\lambda}$	0.0014	0.0011	0.0016**	0.0013**	0.0010***	0.0011***	0.0013	0.0009
	(0.0009)	(0.0009)	(0.0007)	(0.0006)	(0.0001)	(0.0002)	(0.0011)	(0.0008)
$\widehat{\chi}$			0.0026***	0.0028***			0.0028***	0.0022**
			(0.0009)	(0.0008)			(0.0008)	(0.0009)
$\widehat{\varrho}$					−0.6722	1.1463	1.4176	4.3855
					(0.4639)	(1.2385)	(1.2189)	(3.1496)
$\widehat{\pi}$					0.0000	−0.0001*	−0.0001	0.0002
					(0.0000)	(0.0001)	(0.0001)	(0.0002)
$\widehat{\xi}$	−0.7828***	−0.7542***	−0.7990***	−0.7987***	−0.7983***	−0.7989***	−0.7987***	−0.8010***
	(0.0262)	(0.0579)	(0.0014)	(0.0012)	(0.0014)	(0.0013)	(0.0013)	(0.0018)
Obs. [N]	1,248 [56]	1,029 [51]	1,136 [56]	708 [33]	1,080 [51]	331 [12]	1,077 [51]	329 [12]
RMSE	0.00749	0.00591	7.19e-10	6.23e-10	6.72e-10	6.45e-10	5.74e-10	5.56e-10
CSD p-value	0.00111	0.561	0.0296	0.363	0.551	0.547	0.0244	0.667

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$, $\widehat{\tau}$, $\widehat{\Phi}$, and $\widehat{\pi}$ are the long-run coefficients associated with GDP per capita, openness index, labour force and inflation rate, respectively
Source(s): The author's own elaboration

Table A8. Estimates, pre and post 2007, PMG

CSA lags	Model A: No CSA	Model A: 0	Model A: 1	Model A: 2	Model A: 3	Model B: No CSA	Model B: 0	Model B: 1	Model B: 2	Model B: 3
<2008										
$\widehat{\rho}_i$	0.2244***	0.2228***	0.1897***	0.1729***	0.1595***	0.1911***	0.1896***	0.1540***	0.0953	–
	(0.0370)	(0.0441)	(0.0170)	(0.0232)	(0.0338)	(0.0173)	(0.0197)	(0.0388)	(0.0757)	–
$\widehat{\beta}_i$	0.0002	−0.0001	0.0008	0.0011	0.0010	0.0012***	0.0011***	0.0014***	0.0010***	–
	(0.0008)	(0.0013)	(0.0008)	(0.0010)	(0.0009)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	–
$\widehat{\lambda}$	0.0005	0.0011	0.0018	0.0014	0.0014	0.0014	0.0013	0.0026***	0.0031**	–
	(0.0008)	(0.0010)	(0.0011)	(0.0009)	(0.0009)	(0.0011)	(0.0019)	(0.0008)	(0.0012)	–
$\widehat{\chi}$						0.0023**	0.0029***	0.0041***	0.0031***	–
						(0.0009)	(0.0009)	(0.0010)	(0.0011)	–
$\widehat{\xi}$	−0.7409***	−0.7159***	−0.7858***	−0.8080***	−0.7953***	−0.7866***	−0.7904***	−0.8143***	−0.8427***	–
	(0.0633)	(0.0983)	(0.0209)	(0.0195)	(0.0437)	(0.0234)	(0.0106)	(0.0319)	(0.0218)	–
Obs. [N]	726 [48]	712 [46]	589 [37]	424 [23]	381 [21]	712 [46]	468 [24]	398 [20]	298 [14]	–
RMSE	0.00462	0.00464	0.00348	0.00344	0.00320	0.00381	0.00322	0.00302	0.00197	–
CSD p-value	5.84e-05	0.421	0.168	0.191	0.301	0.126	0.726	0.737	0.274	–
≥2008										
$\widehat{\rho}_i$	0.2367***	0.2366***	0.2080***	–	–	0.2392***	0.2220***	–	–	–
	(0.0140)	(0.0164)	(0.0169)	–	–	(0.0144)	(0.0189)	–	–	–
$\widehat{\beta}_i$	0.0008	0.0007	0.0008	–	–	0.0007	0.0007	–	–	–
	(0.0006)	(0.0005)	(0.0007)	–	–	(0.0006)	(0.0005)	–	–	–
$\widehat{\lambda}$	0.0009*	0.0007	0.0006	–	–	0.0024***	0.0020***	–	–	–
	(0.0005)	(0.0006)	(0.0005)	–	–	(0.0007)	(0.0005)	–	–	–
$\widehat{\chi}$			–	–	–	0.0017***	0.0017***	–	–	–
			–	–	–	(0.0007)	(0.0006)	–	–	–
$\widehat{\xi}$	−0.7972***	−0.7872***	−0.8038***	–	–	−0.7914***	−0.7936***	–	–	–
	(0.0222)	(0.0167)	(0.0295)	–	–	(0.0218)	(0.0233)	–	–	–
Obs. [N]	876 [73]	876 [73]	803 [73]	–	–	876 [73]	864 [72]	–	–	–
RMSE	0.00698	0.00582	0.00530	–	–	0.00684	0.00564	–	–	–
CSD p-value	0.000718	0.0893	0.781	–	–	0.0318	0.118	–	–	–

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$ is the long-run coefficient associated with GDP per capita

Source(s): The author's own elaboration

Table A9.
Estimates, pre and post 2007, MG

CSA lags	Model A No CSA	0	1	2	3	Model B No CSA	0	1	2	3
<2008										
$\widehat{\rho}_i$	0.1996***	0.1988***	0.1996***	0.2000***	0.2008***	0.1996***	0.2003***	0.2018***	0.2008***	–
	(0.0009)	(0.0012)	(0.0010)	(0.0011)	(0.0011)	(0.0010)	(0.0011)	(0.0012)	(0.0013)	–
$\widehat{\beta}_i$	0.0004	0.0000	0.0004	0.0006	0.0011*	0.0004	0.0008	0.0015**	0.0011	–
	(0.0004)	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.0006)	–
$\widehat{\lambda}$	0.0025***	0.0024***	0.0017***	0.0017***	0.0008	0.0017***	0.0012	0.0017***	0.0019***	–
	(0.0006)	(0.0006)	(0.0005)	(0.0006)	(0.0009)	(0.0005)	(0.0007)	(0.0006)	(0.0007)	–
$\widehat{\chi}$						0.0017***	0.0021***	0.0031***	0.0025**	–
						(0.0006)	(0.0007)	(0.0008)	(0.0008)	–
$\widehat{\xi}$	0.0017***	−0.8012***	−0.8004***	−0.8000***	−0.7992***	−0.8004***	−0.7997***	−0.7982***	−0.7992***	–
	(0.0009)	(0.0012)	(0.0010)	(0.0011)	(0.0011)	(0.0010)	(0.0011)	(0.0012)	(0.0013)	–
Obs. [N]	726 [48]	712 [46]	589 [37]	424 [23]	381 [21]	712 [46]	468 [24]	398 [20]	298 [14]	–
RMSE	5.41e-10	5.17e-10	5.03e-10	5.04e-10	5.10e-10	4.95e-10	4.95e-10	4.63e-10	7.61e-10	–
CSD p-value	0.0033	0.0038	0.0012	0.1482	0.2390	0.0131	0.136	0.168	0.758	–
≥2008										
$\widehat{\rho}_i$	0.2007***	0.2006***	0.2007***	–	–	0.2007***	0.2007***	–	–	–
	(0.0011)	(0.0011)	(0.0011)	–	–	(0.0011)	(0.0011)	–	–	–
$\widehat{\beta}_i$	0.0010*	0.0009*	0.0010*	–	–	0.0010*	0.0010*	–	–	–
	(0.0005)	(0.0006)	(0.0005)	–	–	(0.0005)	(0.0006)	–	–	–
$\widehat{\lambda}$	0.0011**	0.0010**	0.0004	–	–	0.0027***	0.0029***	–	–	–
	(0.0005)	(0.0005)	(0.0004)	–	–	(0.0008)	(0.0010)	–	–	–
$\widehat{\chi}$				–	–	0.0024***	0.0025***	–	–	–
				–	–	(0.0007)	(0.0007)	–	–	–
$\widehat{\xi}$	−0.7993***	−0.7994***	−0.7993***	–	–	−0.7993***	−0.7993***	–	–	–
	(0.0011)	(0.0011)	(0.0011)	–	–	(0.0011)	(0.0011)	–	–	–
Obs. [N]	876 [73]	876 [73]	803 [73]	–	–	872 [73]	862 [72]	–	–	–
RMSE	7.63e-10	6.49e-10	5.86e-10	–	–	7.27e-10	6.57e-10	–	–	–
CSD p-value	0.0624	0.120	0.731	–	–	0.480	0.995	–	–	–

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$ is the long-run coefficient associated with GDP per capita
Source(s): The author's own elaboration

Table A10. Estimates, pre and post 2011. PMG

	Model A					Model B				
CSA lags	No CSA	0	1	2	3	No CSA	0	1	2	3
<2011										
$\widehat{\rho}_i$	0.2101***	0.2084***	0.2098***	0.2214***	0.2190***	0.2217***	0.1942***	0.2052***	0.1932***	0.1897***
	(0.0122)	(0.0140)	(0.0214)	(0.0464)	(0.0686)	(0.0155)	(0.0199)	(0.0146)	(0.0212)	(0.0230)
$\widehat{\beta}_i$	0.0006	0.0003	0.0004	−0.0000	−0.0005	0.0005	0.0005	−0.0002	0.0004	0.0006
	(0.0005)	(0.0006)	(0.0007)	(0.0008)	(0.0011)	(0.0006)	(0.0006)	(0.0010)	(0.0008)	(0.0009)
$\widehat{\lambda}$	0.0019***	0.0013*	0.0014	0.0008	−0.0002	0.0019**	0.0015	0.0025***	0.0027***	0.0022***
	(0.0006)	(0.0007)	(0.0009)	(0.0010)	(0.0015)	(0.0008)	(0.0011)	(0.0007)	(0.0010)	(0.0008)
$\widehat{\chi}$						0.0011	0.0027***	0.0021**	0.0024*	0.0017*
						(0.0012)	(0.0009)	(0.0009)	(0.0012)	(0.0009)
$\widehat{\xi}$	−0.7673***	−0.7503***	−0.7269***	−0.7232***	−0.7186***	−0.7499***	−0.7668***	−0.7463***	−0.7898***	−0.7904***
	(0.0182)	(0.0252)	(0.0489)	(0.0793)	(0.1351)	(0.0268)	(0.0293)	(0.0487)	(0.0193)	(0.0448)
Obs. [*N*]	1,028 [67]	969 [59]	804 [46]	718 [42]	494 [25]	969 [59]	821 [45]	516 [24]	438 [20]	326 [14]
RMSE	0.00627	0.00549	0.00495	0.00497	0.00523	0.00604	0.00506	0.00460	0.00355	0.00340
CSD *p*-value	0.000	0.0234	0.00277	0.0500	0.417	2.17e-06	0.116	0.000458	0.865	0.159
≥2011										
$\widehat{\rho}_i$	0.2265***	–	–	–	–	0.2007***	–	–	–	–
	(0.0170)	–	–	–	–	(0.0011)	–	–	–	–
$\widehat{\beta}_i$	0.0008	–	–	–	–	0.0010*	–	–	–	–
	(0.0005)	–	–	–	–	(0.0005)	–	–	–	–
$\widehat{\lambda}$	0.0012*	–	–	–	–	0.0021***	–	–	–	–
	(0.0006)	–	–	–	–	(0.0005)	–	–	–	–
$\widehat{\chi}$		–	–	–	–	0.0016***	–	–	–	–
		–	–	–	–	(0.0006)	–	–	–	–
$\widehat{\xi}$	−0.8044***	–	–	–	–	−0.7993***	–	–	–	–
	(0.0271)	–	–	–	–	(0.0011)	–	–	–	–
Obs. [*N*]	657 [73]	–	–	–	–	648 [73]	–	–	–	–
RMSE	0.00551	–	–	–	–	5.06e-10	–	–	–	–
CSD *p*-value	1.33e-10	–	–	–	–	0.488	–	–	–	–

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The *p*-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$ is the long-run coefficient associated with GDP per capita
Source(s): The author's own elaboration

Table A11.
Estimates, pre and post 2011. MG

CSA lags	Model A No CSA	Model A 0	Model A 1	Model A 2	Model A 3	Model B No CSA	Model B 0	Model B 1	Model B 2	Model B 3
<2011										
$\widehat{\rho}_i$	0.2016***	0.2007***	0.2007***	0.2201***	0.1933***	0.2007***	0.2008***	0.1989***	0.1998***	0.2003***
	(0.0010)	(0.0010)	(0.0009)	(0.0150)	(0.0037)	(0.0010)	(0.0009)	(0.0011)	(0.0011)	(0.0011)
$\widehat{\beta}_i$	0.0010**	0.0007*	0.0000	0.0004	0.0008	0.0010**	0.0011**	0.0001	0.0005	0.0008
	(0.0005)	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0006)	(0.0005)	(0.0006)
$\widehat{\lambda}$	0.0030***	0.0024***	0.0024***	0.0018***	0.0011	0.0024***	0.0020***	0.0012*	0.0017***	0.0022***
	(0.0007)	(0.0006)	(0.0006)	(0.0005)	(0.0007)	(0.0006)	(0.0005)	(0.0007)	(0.0006)	(0.0007)
$\widehat{\chi}$						0.0024***	0.0025***	0.0013*	0.0018***	0.0021***
						(0.0006)	(0.0006)	(0.0007)	(0.0007)	(0.0007)
$\widehat{\xi}$	−0.7984***	−0.7993***	−0.7993***	−0.6613***	−0.8034***	−0.7993***	−0.7992***	−0.8011***	−0.8002***	−0.7997***
	(0.0010)	(0.0010)	(0.0009)	(0.1326)	(0.0057)	(0.0010)	(0.0009)	(0.0011)	(0.0011)	(0.0011)
Obs. [N]	1,028 [67]	969 [59]	804 [46]	718 [42]	494 [25]	969 [59]	821 [45]	516 [24]	438 [20]	326 [14]
RMSE	7.08e-10	6.65e-10	6.05e-10	5.87e-10	5.78e-10	6.89e-10	6.29e-10	5.84e-10	5.12e-10	5.25e-10
CSD p-value	0.112	0.444	0.120	0.105	0.598	0.000607	0.0121	0.459	0.501	0.683
≥2011										
$\widehat{\rho}_i$	0.2007***	–	–	–	–	0.1677***	–	–	–	–
	(0.0011)	–	–	–	–	(0.0327)	–	–	–	–
$\widehat{\beta}_i$	0.0010*	–	–	–	–	0.0003	–	–	–	–
	(0.0005)	–	–	–	–	(0.0012)	–	–	–	–
$\widehat{\lambda}$	0.0017*	–	–	–	–	0.0024***	–	–	–	–
	(0.0009)	–	–	–	–	(0.0007)	–	–	–	–
$\widehat{\chi}$		–	–	–	–	0.0024***	–	–	–	–
		–	–	–	–	(0.0007)	–	–	–	–
$\widehat{\xi}$	−0.7993***	–	–	–	–	−0.8382***	–	–	–	–
	(0.0011)	–	–	–	–	(0.0317)	–	–	–	–
Obs. [N]	657 [73]	–	–	–	–	648 [73]	–	–	–	–
RMSE	7.95e-10	–	–	–	–	0.00252	–	–	–	–
CSD p-value	0.938	–	–	–	–	0.661	–	–	–	–

Note(s): The asterisks ***, **, * denote significance at 1%, 5% and 10%, respectively. Linear country-specific trends are included in the models. The square brackets report the standard errors. The p-values of the cross-sectional dependence test (CSD) are reported. RMSE is the root mean squared error. CSA refers to the cross-sectional averages. $\widehat{\chi}$ is the long-run coefficient associated with GDP per capita
Source(s): The author's own elaboration