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The relationship between public debt and economic growth in advanced, emerging and developing economies: Differences and determining factors (*)

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ÍNDICE

Resumen

Examinamos el vínculo heterogéneo y dinámico entre deuda pública y crecimiento económico, utilizando una muestra que comprende 115 economías avanzadas, emergentes y en desarrollo durante 1995-2016 aplicando una extensión del método GFE (Bonhomme y Manresa, 2015b). El objetivo es explorar cómo difiere la relación a lo largo del tiempo entre grupos de países y qué variables podrían explicarla. Los resultados indican que el impacto se ve mitigado por la calidad de las instituciones del país, pero se intensifica con el nivel global de endeudamiento, el vencimiento a corto plazo de la deuda y el tipo de gasto ésta financia.

Abstract

We examine the dynamic heterogeneous link between public debt and economic growth, using a sample that comprises 115 advanced, emerging and developing economies during 1995-2016 by applying an extension of the GFE method (Bonhomme and Manresa, 2015b). Our goal is to explore how the relationship differs over time between groups of countries and which variables might explain it. Our results indicate that the likelihood of a strong impact is mitigated by the quality of a country's institutions but intensified by the global level of indebtedness, the maturity of the debt, and the type of expenditure that is funded with debt.

Keywords: Public debt; Economic growth; Dynamic heterogeneity; Grouped fixed-effects; Panel data; Panel regression analysis.

JEL classification codes: C23, F34, H63, O47.

1. INTRODUCTION

In 2020, a decade after the global financial crisis, the COVID-19 pandemic struck amid preexisting government debt-to-GDP ratios still above their pre-crisis levels. Indeed, according to the World Bank, prior to the pandemic, starting in 2010, the fourth wave of global debt accumulation was underway, with the largest, fastest, and most broad-based increase in global debt in five decades[1]. So, amid the fourth wave of global debt, the COVID-19 pandemic caused a global recession whose depth was only surpassed by the two World Wars and the Great Depression over the past century and a half (global economic activity registered an estimated 3.2% contraction in 2020 according to July 2021 IMF World Economic Outlook). As economic activity collapsed, governments acted quickly to provide support during the pandemic. This support together with economic contraction led to increasing fiscal deficits[2] and public debt. In 2020, we observed the largest one-year debt surge since World War II with global debt rising by 28 percentage points to 256 percent of GDP (see IMF's Global Debt Database[3]).

Consequently, the pandemic made the fourth wave of debt even more dangerous by increasing its risky features since the debt surge amplifies vulnerabilities, especially as financing conditions might tighten in the future. Indeed, debt-to-GDP ratios have rapidly reached new highs. Borrowing by governments accounted for slightly more than half of the increase, as the global public debt ratio jumped to a record 99 percent of GDP and public debt now accounts for almost 40 percent of total global debt, the highest share since the mid-1960s (debt increases are particularly striking in advanced economies, where public debt rose from around 70 percent of GDP, in 2007, to 124 percent of GDP, in 2020).

In this environment, the analysis of the relationship between public debt and economic growth has regained relevance for economists. The existing literature has grouped empirical studies into two generations of papers (see Mitze and Matz, 2015). The "first generation" includes the works by Reinhart and Rogoff (2010), Pattillo *et al*., (2011), Lof and Malinen (2014) and Woo and Kumar (2015), among others. These papers defended the existence of an inverted U-shape relationship between public debt and economic growth (debt begins to damage growth when the debt-to-GDP ratio exceeds a given threshold – 90%, according to the seminal paper by Reinhart and Rogoff (2010)– since they mainly focused on the nonlinear relationship between the two variables.

Nonetheless, the "second generation" of papers goes beyond the nonlinearities and centers instead on the heterogeneity of the debt-growth relationship across countries. [Ghosh *et al*. (2013), Pescatori *et al.* (2014), Eberhardt and Presbitero (2015), Markus and Rainer (2016), Chudik *et al.* (2017), Chiu and Lee (2017) or Gómez-Puig and Sosvilla-Rivero (2017, 2018a)]. The papers in

[1] See WORLD BANK (2020).

[2] Average overall deficits as a share of GDP reached, in 2020, levels of 10.9 per cent for advanced economies, 9.7 per cent for emerging market and middle-income economies, and 5.5 per cent for low-income developing countries (IMF World Economic Outlook, July 2021).

[3] See https://blogs.imf.org/2021/12/15/global-debt-reaches-a-record-226-trillion/

this group admit a heterogeneous impact of government debt on growth depending on country-specific macroeconomic, financial and institutional variables.

In this context, Gómez-Puig *et al.* (2022) have recently investigated and quantified the heterogeneity of the debt-growth nexus across countries using panel data for 115 countries over the 1995-2016 period applying the grouped fixed effects (GFE) estimator proposed by Bonhomme and Manresa (2015a). This methodology allows them to endogenously identify five groups of countries with a distinct relationship between the public debt-to-GDP ratio and economic growth. Nonetheless, the empirical results presented in that paper were average values for the entire sample period and did not explore the time-varying impact of public debt on growth in the country groups identified.

Given the capability of the GFE estimator to take into account the possibility that different countries experience distinct dynamics in the debt-growth relationship, with the group-specific time patterns and individual group membership being left unrestricted and estimated from the data[4], the objective of this paper is twofold. The main objective is to examine the possibility of the existence of a time-variation in the parameter relating the public debt variable to the real growth rate, therefore giving further evidence of heterogeneities in both the temporal and country impact of public debt on economic performance. Once the empirical relevance of dynamic heterogeneous links between public debt and economic growth has been established, we turn to our secondary objective and examine the determinants of the time-varying magnitude of such heterogeneous links. By performing a panel data analysis, we assess the role of five types of variables: (1) the quality of institutions, (2) private indebtedness, (3) public indebtedness, (4) the composition of debt-funded public expenditure, and (5) the maturity of the debt. Therefore, our analysis represents an important contribution to the existing literature since, as far as we know, this is the first paper that analyses the heterogeneities in the debt-growth nexus, not only across countries, but also over time, shedding further light on the heterogeneous link between public debt and economic growth.

The paper proceeds in the following structure. Section 2 discusses the analytical framework. In Section 3, we describe our dataset. Section 4 reports the econometric methodology, while Section 5 presents the empirical results. Finally, Section 6 provides some concluding remarks.

2. ANALYTICAL FRAMEWORK

As mentioned, Gómez-Puig *et al.* (2022) investigate the heterogeneity of the debt-growth relationship across countries using panel data for a wide sample of countries over a 22-year period applying the grouped fixed effects (GFE) estimator proposed by Bonhomme and Manresa (2015a). In their paper, the debt-growth nexus is examined considering a Solow model augmented with public debt, where the growth rate of real per capita GDP for a given country i in time t (g_{ti}) is given by:

[4] Furthermore, the GFE estimator arguably deals better with endogeneity due to unobserved heterogeneity.

$$g_{it} = \alpha + \gamma y_{it-1} + \sum_{j=1}^{n} \delta_{ij} X_{ijt} + \beta d_{it} + \varepsilon_{it}, \ \text{i=1,...,N, t=1,...,T.} \quad (1)$$

where y_{it-1} is the logarithm of initial real *per capita* GDP (to capture the "catch-up effect" or conditional convergence of the economy to its steady state), X_{ijt} (j=1, ..., n) is a set of control variables, d_{ti} is the public debt-to-GDP ratio, and ε_{it} denotes the error term.

Regarding X_{it}, a set of explanatory variables that are consistently associated with growth in the literature is considered [see, e.g., Aghion and Howitt (2009) or Sachs and Warner (1997)]: (i) population growth rate as a percentage ($POPGR_t$); (ii) the ratio of gross capital formation to GDP (GCF_t); (iii) life expectancy at birth, a proxy for the level of human capital (HK_t); (iv) openness to trade, measured by the sum of exports and imports over GDP ($OPEN_t$); (v) the GDP deflator inflation rate, a measure of macroeconomic instability and uncertainty (INF_t); and (vi) a traditional indicator of financial depth (FIN_t).

Population growth ($POPGR_t$) and the ratio of gross fixed capital formation to real GDP (GCF_t) are used to proxy the rate of labour growth and the accumulation of the physical capital stock, respectively, since these two variables are the main determinants of economic growth in the literature (Solow (1956) and Frankel (1962), among others). A proxy of human capital (HK_t) is included to reflect that investment's attraction and engagement in innovation activities are higher the higher the human capital is (Grossman and Helpman, 1991). With regards to trade openness ($OPEN_t$) and the inflation rate (INF_t), they have been included in the model because the former is supposed to improve productivity through efficiency gains (Seghezza and Baldwin, 2008) while some authors [see Fischer (1993) or Barro (2003), among other authors] have argued that inflation is a good indicator of how the government manages the economy and that low inflation brings about economic efficiency because economies can allocate, through the price mechanism, scarce resources to their best economic use (World Bank, 1990). Finally, given that the level of debt that a country can sustain without negative impacts also depends on the development of financial markets, following King and Levine (1993) or Beck *et al*. (2000), we also introduce the ratio of liquid liabilities to GDP (FIN_t) as an indicator of financial development. In particular, (FIN_t) equals liquid liabilities of banks and other financial intermediaries divided by GDP and is used as a measure of "financial depth" and thus of the overall size of the financial intermediation sector (it includes all banks and non-bank financial institutions).

Nonetheless, the empirical results presented in Gómez-Puig *et al.* (2022) were average values for the entire sample period (1995-2016) and did not deepen on the time-varying effect of public debt on economic performance in the country groups identified. So, in this paper, we part from the results of that paper, but our analysis goes beyond, since and our main objective is to examine the presence of group-specific time-varying effects of public debt on economic growth. To that end, we use the heterogeneous coefficients extension of the GFE model proposed by Bonhomme and Manresa (2015b) that will be explained in Section 4. Subsequently, we turn to our secondary objective and will examine the determinants of the time-varying magnitude of such heterogeneous links considering five types of variables that gauge: (1) the quality of institutions, (2) the rela-

tive public indebtedness, (3) the relative private indebtedness, (4) debt maturity and (5) the composition of public expenditure that is funded with debt.

The institutional quality is an important contextual factor. The rising government debt, coupled with good institutional quality, might generate a different economic growth impact. The relevance of sound and efficient institutions in explaining long-run growth was formalized in several contributions in the early 2000s (see Acemoglu *et al*. 2001, 2002, 2005a and 2005b). These papers provided evidence that, while good institutions might attract investment and reduce uncertainty for economic decision-makers offering incentives for innovative and productive activities, countries with weaker institutions find it harder to sustain growth and are more vulnerable to experiencing periods of crisis and stagnation. However, the role played by institutions in explaining the relationship between debt and growth has for the most part been ignored. There are some exceptions, though [see Jalles (2011), Kourtellos *et al*. (2013), Kim *et al*. (2017), Tarek and Ahmed (2017) and Sani *et al.* (2019)], finding that these factors have a significant and prominent role in the debt-economic growth relationships. In particular, Sani *et al.* (2019) argued that good institutional quality is necessary to minimise the negative effect of debt on the economy by ensuring debt effectiveness. Meanwhile, Tarek and Ahmed (2017) found that low institutional quality implies macroeconomic condition cost. So, following these authors, we include the quality of institutions (GQI_t) as a potential driver of a heterogeneous relationship. According to Acemoglu *et al.* (2005a) economic institutions are identified with the structure of property rights and access to economic resources (if they are good, they will provide security of property rights and relatively equal access to economic resources to a wide sector of society). Nonetheless, measuring its quality is a challenging task and it is common practice in the literature to gauge it in terms of perceptions (which may not reflect the quality of the law but rather the actual workings of the economy). This is the reason why we use the World Bank's Worldwide Governance Indicator (WGI), which is a composite index that offers better time-variant characteristics than other governance measures.

Regarding the relevance of private debt ($PRDEBT_t$), we should recall that according to the Global Debt Database published by the IMF, of the global total debt at the end of 2020 ($226 trillion in nominal terms, the equivalent of 256% of GDP), 60 percent was nonfinancial private debt (held by households and nonfinancial corporations), whilst the remaining 40 percent was public debt. However, while all forms of debt, when high and growing, are sources of justifiable concern, studies examining the impact of public debt on economic growth are far more numerous than those assessing the risks of private debt accumulation [Cecchetti *et al.* (2011), Lombardi *et al*. (2017) and Gómez-Puig and Sosvilla-Rivero (2018) are some of the exceptions]. Nevertheless, the negative implications of excessive private debt (a "debt overhang") for growth and financial stability are well documented in the literature. As private debt levels increase, borrowers' ability to repay becomes progressively more sensitive to falls in income and sales as well as to increases in interest rates. In fact, high private debt can have a substantial adverse impact on macroeconomic performance and stability, as it hinders the ability of households to smooth their consumption and affects corporations' investments [see, e.g., Schularick and Taylor (2012), Jordà *et al.* (2016) and International Monetary Fund (2016)].

Moreover, some authors (see, e.g., Fatás *et al*. (2019)) state that one of the reasons why it is difficult to pin down the causal effect of debt on economic growth is that not all debts are equal. In this sense, Rodrik and Velasco (1999), Detragiache and Spilimbergo (2002) and Jeanne (2009) argue that debt maturity is a key element that can affect the heterogeneous impact of debt on growth. So, we have introduced short-term debt expressed as a percentage of total external debt (STD_t) as a proxy of debt maturity.

Finally, with regards the relationship between government expenditure composition and economic growth, although there is an extensive literature on this subject, as far as we know, no empirical paper has examined the effect of those variables in the debt-growth relationship. In a framework of endogenous growth, the Barro (1990 and 1991) postulates that the growth effect of government spending depends on how the government spending is allocated and executed., predicting that the unproductive governmental spending will lower the growth rate of GDP, while the effect of productive government expenditure on the growth rate of GDP is ambiguous, depending on how the government behaves and on whether the expenditure ratio is too little or too much. In the same vein, Devarajan *et al*. (1996), Aschauer (1989) and Kneller *et al.* (1999) point out that the impact of public debt on the economy's performance may depend on whether the public expenditure funded by government debt is productive or unproductive. Productive expenditure, which includes physical infrastructure (roads and railways), communication, information systems (phone, internet), education or health, may have a positive impact on private sector productivity and the growth rate of the economy. However, non-productive expenditure (which normally effects on citizens' welfare) does not affect the economy's long-run performance and may lead, in some cases, to public debt levels that are difficult to justify.

3. DATA

We build a balanced panel of annual data for 115 countries –including advanced economies, emerging market economies and low-income developing countries– over the period 1995-2016 (see Table 1).

Table 1

LIST OF 115 COUNTRIES INCLUDED IN THE SAMPLE BY INCOME GROUP

Income group	Countries
29 Low income developing countries (LIDC)	Burkina Faso, Cameroon, Cape Verde, Comoros, Congo Republic, Congo Democratic Republic, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guyana, Haiti, Honduras, Kenya, Kyrgyz Republic, Madagascar, Malawi, Mali, Mauritania, Moldova, Nepal, Nicaragua, Niger, Nigeria, Rwanda, Senegal, Sudan, Tanzania, Uganda.
54 Emerging market economies (EM)	Algeria, Argentina, The Bahamas, Bahrain, Barbados, Belarus, Belize, Bolivia, Botswana, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Croatia, Dominican Republic, Ecuador, Egypt, El Salvador, Eswatini, Fiji, Gabon, Guatemala, Hungary, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, Malaysia, Mauritius, Mexico, Morocco, Namibia, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Seychelles, South Africa, Sri Lanka, Thailand, Tunisia, Turkey, Ukraine, Uruguay.
32 Advanced economies (AE)	Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea Republic, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States.

Note: The main criteria used by the International Monetary Fund to classify the world into advanced economies, emerging market and developing economies are (1) per capita income level, (2) export diversification — thus, oil exporters that have high real *per capita* GDP would not make the advanced classification because around 70% of its exports are oil; and (3) degree of integration in the global financial system.

In the first step, to maintain as much homogeneity as possible for a sample of 115 countries over the course of two decades, we use the World Bank's World Development Indicators as our primary source. We then strengthen our data with the use of supplementary information from the International Monetary Fund (International Financial Statistics and World Economic Outlook, October 2018). As mentioned above, we first use real per capita real GDP, population growth rate, the ratio of gross capital formation to GDP, an index of human capital, openness to trade, GDP deflator inflation, and the ratio of liquid liabilities to GDP to examine the impact of debt on economic growth. The definitions and sources of the variables are presented in Table 2, while Table 3 presents definitions and sources of the variables used to examine the potential drivers of the heterogeneous time-varying debt-growth relationship.

Table 2

EXPLANATORY VARIABLES AND DATA SOURCES USED IN THE GFE ESTIMATION

Variable	Description	Source
Real growth rate (*g*)	Growth rate of real *per capita* GDP (annual %)	World Development Indicators (World Bank)
Level of Output (*y*)	*Per capita* Gross domestic product at 2010 market prices	World Development Indicators (World Bank)
Public debt-to-GDP ratio (*d*)	Ratio of public debt to GDP	World Economic Outlook (International Monetary Fund)
Population growth (*POPGR*)	Population growth (annual %)	World Development Indicators (World Bank)
GCF-to-GDP ratio (*GCF*)	Ratio of gross capital formation to GDP (%)	World Development Indicators (World Bank)
Human capital (*HK*)	Life expectancy at birth, total (years)	World Development Indicators (World Bank)
Openness (*OPEN*)	Absolute sum of exports and imports over GDP	World Development Indicators (World Bank)
Inflation (*INF*)	Inflation as measured by the consumer price index (annual %)	World Development Indicators (World Bank)
Financial development (*FIN*)	Liquid Liabilities to GDP (%)	Financial Development and Structure Dataset (World Bank)

Table 3

EXPLANATORY VARIABLES AND DATA SOURCES USED IN PANEL REGRESSION ANALYSIS

Variable		Description	Source
(GQI) This is an average of the value of the following four indicators, rescaled so that it lies between zero and one.	Government effectiveness *(GE)*	Perceptions of the quality of: public services, civil service and the degree of its independence from political pressures, policy formulation and implementation, and of the credibility of the government's commitment to such policies.	The Worldwide Governance Indicators (World Bank)
	Regulatory Quality *(RQ)*	Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	The Worldwide Governance Indicators (World Bank)
	Rule of law *(RL)*	Perceptions of the extent to which agents have confidence in and abide by the rules of society (the quality of contract enforcement, property rights, the police, the courts) as well as the likelihood of crime and violence.	The Worldwide Governance Indicators (World Bank)
	Control of corruption *(CC)*	Perceptions of the extent to which public power is exercised for private gain, including corruption, as well as "capture" of the state by elites and private interests.	The Worldwide Governance Indicators (World Bank)
(DQPD) Dummy variable that takes values 1 to 4 corresponding to low, low-middle, upper-middle, and high indebted countries	Public Debt-to-GDP *(PUBDEBT or d)*	Ratio of public debt over GDP	World Development Indicators (World Bank)
(DQPRD) Dummy variable that takes values 1 to 4 corresponding to low, low-middle, upper-middle, and high indebted countries	Private Debt-to-GDP *(PRDEBT)*	This variable is calculated as the sum of two components: (1) bank loans to domestic households and nonfinancial corporations, drawn from the IMF's Standardized Reporting Forms (SRFs) and International Financial Statistics (IFS) and (2) the outstanding stock of debt securities issued (on the domestic and international markets) by non-financial corporations, calculated based on securities issuance data from Dealogic database.	Global Debt Database (International Monetary Fund)
(STD) Debt maturity		Short term debt expressed as a percentage of total external debt.	World Development Indicators (World Bank) and Coordinated Portfolio Investment Survey, CPIS (IMF)

Table 3 (continued)

	Variable	Description	Source
Productive Expenditure	General Public Services (*GF01*)	Executive and legislative organs, financial and fiscal affairs, external affairs; foreign economic aid; general services; basic research; R&D related to general public services; general public services not else classified (n.e.c.); public debt transactions, transfers of a general character between different levels of government.	Government Financial Statistics (International Monetary Fund)
	Defence (*GF02*)	Military defence; civil defence; foreign military aid, R&D related to defence; defence n.e.c.	Government Financial Statistics (International Monetary Fund)
	Economic affairs (*GF04*)	General economic, commercial and labour affairs; agriculture, forestry; fishing and hunting; fuel and energy; mining, manufacturing and construction; transport; communication; other industries, R&D related to economic affairs; economic affairs n.e.c.	Government Financial Statistics (International Monetary Fund)
	Housing and community amenities (*GF06*)	Housing development; community development; water supply; street lighting; R&D related to housing and community amenities; housing and community amenities n.e.c.	Government Financial Statistics (International Monetary Fund)
	Health (*GF07*)	Medical products, appliances and equipment; outpatient services; hospital services; public health services; R&D related to health; health n.e.c.	Government Financial Statistics (International Monetary Fund)
	Education (*GF09*)	Pre-primary, primary, secondary and tertiary education, post-secondary non-tertiary education, education non definable by level, subsidiary services to education, R&D; n.e.c.	Government Financial Statistics (International Monetary Fund)
Unproductive Expenditure	Public order and safety (*GF03*)	Police services; fire-protection services; law courts; prisons; R&D related to public order and safety; public order and safety n.e.c.	Government Financial Statistics (International Monetary Fund)
	Environment protection (*GF05*)	Waste management; water waste management; pollution abatement; protection of biodiversity and landscape; R&D related to environmental protection.	Government Financial Statistics (International Monetary Fund)
	Recreation, culture and religion (*GF08*)	Recreational and sporting services; cultural services; broadcasting and publishing services; religious and other community services, R&D related to recreation, culture and religion; recreation; culture and religion n.e.c.	Government Financial Statistics (International Monetary Fund)
	Social protection (*GF10*)	Sickness and disability; old age; survivors; family and children; unemployment; housing; R&D; social protection and social exclusion n.e.c.	Government Financial Statistics (International Monetary Fund)

The WGI index is used to build up our proxy of the quality of institutions (GQI_t). This World Bank index covers six broad dimensions of governance for over 200 countries since 1996 and summarizes views on the quality of country governance provided by a wide variety of survey organizations worldwide (non-governmental or public sector among them). It is updated annually following the methodology of Kaufmann *et al*. (2010). The six governance dimensions are: (1) voice and accountability, (2) political stability and absence of violence, (3) government effectiveness, (4) regulatory quality, (5) rule of law, and (6) control of corruption. From them, we have selected the last four dimensions (the definition of each of the four indicators included in our average measures is presented in Table 3) since they are the measures primarily concerned with the quality of the delivery of government services (see Helliwell *et al.*, 2014). Then, following Chong and Gradstein (2007) and Beltratti and Stulz (2012), we take the simple average of them for each country and year. We then rescale this raw score so that it lies between zero and one by subtracting the minimum score from it and dividing the result by the maximum score minus the minimum score. This variable is named "government quality indicator" (GQI_t) in our analysis.

Private debt ($PRDEBT_t$) as a percentage of GDP's data have been drawn from the IMF Global Debt Database, which offers the total gross debt of the nonfinancial sector (private and public) for an unbalanced panel of 190 countries (see Mbaye *et al*., 2018), including the 115 countries of our sample. Then, as explained in Table 3, just as the World Bank classifies countries by income (see Fantom and Serajuddi, 2016), we have classified them as low indebted, lower-middle indebted, upper-middle indebted, and high indebted, the cut-off points between each of the groups being the first, the second and the third quartiles. To this end, we use yearly data to create two dummy variables representing our proxies of the relative public and private indebtedness: ($DQPD_t$) and ($DQPRD_t$), respectively. These dummy variables take values from 1 to 4, corresponding to the low indebted, lower-middle indebted, upper-middle indebted, and high indebted categories using public and private debt-to-GDP ratios respectively.

The short-term debt expressed as a percentage of total external debt (STD_t) is used as a proxy of debt maturity and data have been obtained from the World Bank's World Development Indicators and from the Coordinated Portfolio Investment Survey (CPIS) database provided by the IMF.

Finally, regarding the government expenditure composition's data, the International Monetary Fund Government Financial Statistics was the source used to collect them. This dataset is usually known as the classification of the functions of government (COFOG) and divides government expenditure into 10 categories. Although the impact on the time-varying debt-growth relationship of each of the 10 categories of spending is examined independently, following common practice in literature (see, e. g., Kneller *et al.,* 1999; Adam and Bevan, 2005; Christie, 2012; or Chu *et al*., 2020), we distinguish between productive expenditures and unproductive expenditures. The first group includes general public services *(GF01)*, defence *(GF02)*, economic affairs *(GF04)*, health *(GF07)*, housing and community amenities *(GF06)*, and education *(GF09)* –it includes transport

and communication–, while the latter encompasses public order and safety *(GF03)*, environment protection *(GF05)*, recreation, culture and religion *(GF08)* and social protection *(GF10)*[5].

To produce a data matrix without missing values, we apply two complementary procedures: the technique of multiple imputation developed by King *et al*. (2001) (which permits the approximation of missing data and allows us to obtain better estimates) and the simultaneous nearest-neighbour predictors proposed by Fernandez-Rodriguez *et al.* (1999) (which infers omitted values from patterns detected in other simultaneous time series).

4. ECONOMETRIC METHODOLOGY

In order to examine the presence of group-specific time-varying effects of public debt on economic growth, we use the heterogeneous coefficients extension of the GFE model proposed by Bonhomme and Manresa (2015b). The GFE estimator relaxes the strict assumption that the outcome variable follows the same time trend for all countries and introduces time-varying grouped patterns of heterogeneity in linear panel data models, which is very important to establish whether the relationship under study is heterogeneous across groups of countries. The estimator minimizes a least-squares criterion with respect to all possible groupings of the cross-sectional units.

Both the group-specific time patterns and group membership are estimated from the data. The relationship between observed variables and the unobserved group heterogeneity is unrestricted, allowing for the existence of correlations that would create omitted variable bias in standard fixed-effects estimates.

We consider the following linear model that explains economic growth, g_{it}, with grouped patterns of heterogeneity and takes the form:

$$g_{it} = z_{it}^{'}\theta_{g_{rj}t} + \alpha_{g_{rj}t} + \vartheta_{it} \tag{2}$$

where $g_{r_j} \in [1,...,G]$ denotes group membership, z_{it} are the covariates that are assumed to be contemporaneously uncorrelated with the error term ϑ_{it}, but are allowed to be arbitrarily correlated with group-specific unobserved heterogeneity $\alpha_{g_{rj}}$. The countries in the same group share the same time profile and the number of groups is to be decided or estimated by the researcher and group membership remains constant over time.

In essence, countries that have similar time profiles of growth – net of the explanatory variables – are grouped together. The main underlying assumption is that group membership remains constant over time.

[5] A more detailed overview of the items included in each category is presented in Table 3. In each country, expenditure in the different groups is presented as a percentage of GDP.

The model can be easily modified to allow for additive time-invariant fixed effects, which is our preferred specification[6].

The GFE model (equation 2) is the outcome of the minimization of the following expression:

$$(\hat{\beta},\hat{\alpha},\hat{\gamma}) = \underset{(\beta,\alpha,\gamma)\in\Theta^G x A^{TG} x \Gamma_G}{\arg\min} \sum_{i=1}^{N}\sum_{t=1}^{T}(g_{it} - z_{it}^{'}\beta_{g_{r_j}t} - \alpha_{g_{r_j}t})^2, \quad (3)$$

where the minimum is taken over all possible groupings $\gamma = (g_{r_1},...,g_{r_{1N}})$ of the *N* units into *G* groups, common parameters θ and group-specific time effects α. We denote as γ the set of all $\alpha_{g_{r_{ij}}t}$'s, and as α the set of all g_{r_j}'s. Thus, $\alpha \in \Gamma_G$ denotes a particular grouping of the *N* units, where Γ_G is the set of all groupings of {1,..., *N*} into at most *G* groups.

An alternative characterization, which is based on concentrated group membership variables, is introduced for computational purposes. Then, the optimal group assignment for each country is given by:

$$\hat{g}_{r_i}(\hat{\theta},\hat{\alpha}) = \underset{g_r\in[1,...,G]}{\arg\min} \sum_{t=1}^{T}(g_{it} - z_{it}^{'}\theta_{g_{r_j}t} - \alpha_{g_{r_j}t})^2, \quad (4)$$

where the minimum g_{r_j} is chosen in case of a non-unique solution. The GFE estimator of $(\hat{\theta},\hat{\alpha})$ could be expressed as:

$$(\hat{\theta},\hat{\alpha}) = \underset{(\beta,\alpha)\in\Theta x A^{TG}}{\arg\min} \sum_{i=1}^{N}\sum_{t=1}^{T}(g_{it} - z_{it}^{'}\theta_{g_{r_j}t} - \alpha_{\hat{g}_{r_j}(\beta,\alpha)t})^2, \quad (5)$$

where $\hat{g}_{r_j}(\hat{\theta},\hat{\alpha})$ is given by (equation 3) and the group probabilities are unrestricted and individual-specific.

There are two algorithms available to minimize expression (5). The first one uses a simple iterative strategy and is suitable for small-scale datasets, whereas the second, which exploits recent advances in data clustering, is preferred for larger-scale problems. The former is used in this paper[7].

To determine the optimal number of groups (separately for each outcome variable), we run GFE estimations with a number of groups *G* varying between 1 and 6 and calculate the Bayesian information criterion (BIC) to assess the statistical benefit of having more groups.

As explained, an important feature of the GFE estimator is that group membership of the countries in our sample is not pre-determined, but is estimated according to a least-squares criterion. Countries whose time profiles of the outcome variable (growth rate of real *per capita* GDP) – net

6 The idea is to control not only for time-variant group-specific heterogeneity, but also for time-invariant country-specific unobserved heterogeneity.

7 Very similar results were obtained using the second procedure.

of the effect of covariates – are most similar are grouped together. Assume that the countries in our sample are categorized in a number of groups *J* indexed by *j* = 1, ..., *J*. The number of groups *J* must be small compared to the number of countries. A further advantage of the GFE estimator is that the time-varying GFE is better suited to deal with endogeneity in the presence of time-varying unobserved heterogeneity. In this case, our regression equation takes the following specification:

$$g_{it} = \phi y_{it-1} + \delta_1 INF_{it} + \delta_2 HK_{it} + \delta_3 OPEN_{it} + \delta_4 POPGR_{it} + \delta_5 GCF_{it} + \delta_6 FIN_{it} + \beta_{gr_{jt}} d_{it} + \alpha_{j_i t} + \varepsilon_{it} \quad (6)$$

where $\beta_{gr_{jt}}$ denotes the heterogeneous, time-varying coefficients capturing the impact of public debt on economic growth and $\alpha_{j_i t}$ denotes the group-specific time fixed effect which includes group fixed effects as well as time fixed effects.

Once the groups of countries are determined, in order to control for the possible endogeneity of the public debt-to-GDP ratio, model (6) is estimated using a two-stage least squares methodology with panel corrected standard errors clustered by countries, using the exogenous variables and their lags as instruments. We will refer to this procedure as the GFE-2SLS estimator.

Finally, to explore the potential determinants of the identified heterogeneous dynamic group effects of public debt on growth, we run regressions of the time-varying coefficients of the impact of public debt-to-GDP ratio on economic growth by country groups ($\beta_{gr_{it}}$) on their potential drivers:

$$\beta_{gr_{jt}} = \lambda_1 \mathrm{GQI}_{gr_{jt}} + \lambda_2 \mathrm{DQPD}_{gr_{jt}} + \lambda_3 \mathrm{DQPRD}_{gr_{jt}} + \lambda_4 \mathrm{GF01}_{gr_{jt}} + \lambda_5 \mathrm{GF02}_{gr_{jt}} + ... + \lambda_{13} \mathrm{GF10}_{gr_{jt}} + \lambda_{14} \mathrm{STD}_{gr_{jt}} + \alpha_{j_i t} + \varsigma_{it} \quad (7)$$

where the subscript gr_{jt} denotes the group category.

5. EMPIRICAL RESULTS

In a first step, we start from the analysis presented in Gómez-Puig *et al.* (2022) where, applying the GFE-2SLS method, which controls for individual effects, correlated unobserved heterogeneity, and correlated unobserved heterogeneity, five groups are identified (the number being selected using the information on the change in the criterion function). The estimated classification of the countries belonging to each group is listed in Table 4. As can be seen, Group 1 comprises 18 emerging market economies or low-income countries. Group 2 encompasses 28 countries, being the majority emerging market economies. Group 3 brings together 40 countries, both advanced economies and emerging market economies. Finally, two- thirds of the economies in Groups 4 and 5 are Sub-Saharan Africa low income developing countries.

Table 4

COMPOSITION OF DETECTED GROUPS ORDERED ACCORDING TO THE DEBT COEFFICIENT

GROUP 1:	*Region*	*Income group*	*Other classifications*	*Public indebtedness*	*Private indebtedness*
Belize	Latin America & Caribbean	EM		HI	
Cape Verde	Sub-Saharan Africa	LIDC		HI	LMI
China	East Asia & Pacific	EM	G20	LI	UMI
Congo Rep.	Sub-Saharan Africa	LIDC	OPEC	HI	LI
Egypt, Arab Rep.	Middle East & North Africa	EM	Oil Exporter	HI	LMI
El Salvador	Latin America & Caribbean	EM		LMI	LMI
Eswatini	Sub-Saharan Africa	EM		LI	
Fiji	East Asia & Pacific	EM		LMI	
Guatemala	Latin America & Caribbean	EM		LI	LMI
Guyana	Latin America & Caribbean	LIDC		HI	LMI
Indonesia	East Asia & Pacific	EM	G20; Oil Exporter	LI	LMI
Jordan	Middle East & North Africa	EM		HI	UMI
Morocco	Middle East & North Africa	EM		UMI	UMI
Nigeria	Sub-Saharan Africa	LIDC	OPEC	LI	LI
Paraguay	Latin America & Caribbean	EM		LI	LMI
Sri Lanka	South Asia	EM		HI	LMI
Tunisia	Middle East & North Africa	EM		UMI	
Ukraine	Europe & Central Asia	EM		LMI	UMI

Table 4 (continued)

GROUP 2:	*Region*	*Income group*	*Other classifications*	*Public indebtedness*	*Private indebtedness*
Algeria	Middle East & North Africa	EM	OPEC	LI	LI
Belarus	Europe & Central Asia	EM		LI	
Botswana	Sub-Saharan Africa	EM		LI	LI
Bulgaria	Europe & Central Asia	EM	EU	LI	UMI
Chile	Latin America & Caribbean	EM	OECD	LI	UMI
Colombia	Latin America & Caribbean	EM		LMI	LMI
Costa Rica	Latin America & Caribbean	EM		LMI	LMI
Dominican Rep.	Latin America & Caribbean	EM		LI	LMI
Ecuador	Latin America & Caribbean	EM	OPEC	UMI	LMI
Estonia	Europe & Central Asia	AE	OECD; EMU	LI	HI
Kazakhstan	Europe & Central Asia	EM	Oil Exporter	LI	LMI
Korea, Rep.	East Asia & Pacific	AE	G20; OECD	LI	HI
Latvia	Europe & Central Asia	AE	OECD; EMU	LI	LMI
Lithuania	Europe & Central Asia	AE	EMU	LI	UMI
Malaysia	East Asia & Pacific	EM		UMI	HI
Mauritius	Sub-Saharan Africa	EM		UMI	UMI
Namibia	Sub-Saharan Africa	EM		LI	
Panama	Latin America & Caribbean	EM		UMI	
Peru	Latin America & Caribbean	EM		LMI	LMI
Poland	Europe & Central Asia	EM	OECD; EU	LMI	LMI
Romania	Europe & Central Asia	EM	EU	LI	LMI
Russia	Europe & Central Asia	EM	G20; Oil Exporter	LI	UMI
Seychelles	Sub-Saharan Africa	EM		HI	
Singapore	East Asia & Pacific	AE		HI	HI
Slovak Republic	Europe & Central Asia	AE	OECD; EMU	LMI	UMI
Thailand	East Asia & Pacific	EM		LMI	HI
Turkey	Europe & Central Asia	EM	G20; OECD	LMI	LMI
Uruguay	Latin America & Caribbean	EM		UMI	LMI

Table 4 (continued)

GROUP 3:	*Region*	*Income group*	*Other classifications*	*Public indebtedness*	*Private indebtedness*
Argentina	Latin America & Caribbean	EM	G20	LMI	LMI
Austria	Europe & Central Asia	AE	OECD; EMU	UMI	HI
Bahamas, The	Latin America & Caribbean	EM		LI	HI
Bahrain	Middle East & North Africa	EM		LI	UMI
Barbados	Latin America & Caribbean	EM		HI	
Belgium	Europe & Central Asia	AE	OECD; EMU	HI	HI
Brazil	Latin America & Caribbean	EM	G20	HI	HI
Canada	North America	AE	G20; OECD	HI	HI
Croatia	Europe & Central Asia	EM	EU	LMI	UMI
Cyprus	Europe & Central Asia	AE	EMU	UMI	HI
Czech Republic	Europe & Central Asia	AE	OECD; EU	LI	UMI
Denmark	Europe & Central Asia	AE	OECD; EU	LMI	HI
France	Europe & Central Asia	AE	G20; OECD; EMU	LMI	HI
Gabon	Sub-Saharan Africa	EM	OPEC	UMI	
Germany	Europe & Central Asia	AE	G20; OECD; EMU	UMI	UMI
Greece	Europe & Central Asia	AE	OECD; EMU	HI	UMI
Hungary	Europe & Central Asia	EM	OECD; EU	UMI	UMI
Iceland	Europe & Central Asia	AE	OECD	LMI	HI
Iran, Islamic Rep.	Middle East & North Africa	EM	OPEC	LI	LMI
Ireland	Europe & Central Asia	AE	OECD; EMU	HI	HI
Israel	Middle East & North Africa	AE	OECD	UMI	UMI
Italy	Europe & Central Asia	AE	G20; OECD; EMU	HI	UMI
Jamaica	Latin America & Caribbean	EM		HI	UMI
Japan	East Asia & Pacific	AE	G20; OECD	HI	HI
Luxembourg	Europe & Central Asia	AE	OECD; EMU	LI	HI
Malta	Middle East & North Africa	AE	EMU	UMI	HI
Mexico	Latin America & Caribbean	EM	G20; OECD; Oil Exporter	LMI	LMI
Netherlands	Europe & Central Asia	AE	OECD; EMU	UMI	HI
New Zealand	East Asia & Pacific	AE	OECD	LMI	HI
Norway	Europe & Central Asia	AE	OECD; Oil Exporter	LMI	HI
Oman	Middle East & North Africa	EM	Oil Exporter	LI	UMI
Portugal	Europe & Central Asia	AE	OECD; EMU	UMI	HI
Saudi Arabia	Middle East & North Africa	EM	G20; OPEC	LI	LMI
Slovenia	Europe & Central Asia	AE	EMU	LI	UMI
South Africa	Sub-Saharan Africa	EM	G20	LMI	UMI
Spain	Europe & Central Asia	AE	OECD; EMU	UMI	HI
Sweden	Europe & Central Asia	AE	OECD; EU	LMI	HI
Switzerland	Europe & Central Asia	AE	OECD	UMI	HI
United Kingdom	Europe & Central Asia	AE	G20; OECD	LMI	HI
United States	North America	AE	G20; OECD	UMI	HI

Table 4 (continued)

GROUP 4:	*Region*	*Income group*	*Other classifications*	*Public indebtedness*	*Private indebtedness*
Congo, Dem. Rep.	Sub-Saharan Africa	LIDC		HI	LI
Ghana	Sub-Saharan Africa	LIDC		UMI	LI
India	South Asia	EM	G20	UMI	LMI
Kyrgyz Republic	Europe & Central Asia	LIDC		HI	LI
Malawi	Sub-Saharan Africa	LIDC		UMI	LI
Mauritania	Sub-Saharan Africa	LIDC		HI	LMI
Moldova	Europe & Central Asia	LIDC		LMI	LI
Philippines	East Asia & Pacific	EM		UMI	LMI
Rwanda	Sub-Saharan Africa	LIDC		HI	LI
Sudan	Sub-Saharan Africa	LIDC	Oil Exporter	HI	LI

GROUP 5:	*Region*	*Income group*	*Other classifications*	*Public indebtedness*	*Private indebtedness*
Bolivia	Latin America & Caribbean	EM	Oil Exporter	LMI	
Burkina Faso	Sub-Saharan Africa	LIDC		LMI	LI
Cameroon	Sub-Saharan Africa	LIDC	Oil Exporter	HI	LI
Comoros	Sub-Saharan Africa	LIDC		HI	LI
Cote d'Ivoire	Sub-Saharan Africa	LIDC		HI	LI
Gambia, The	Sub-Saharan Africa	LIDC		UMI	LI
Guinea	Sub-Saharan Africa	LIDC		UMI	LI
Haiti	Latin America & Caribbean	LIDC		LMI	LI
Honduras	Latin America & Caribbean	LIDC		UMI	LMI
Kenya	Sub-Saharan Africa	LIDC		UMI	LMI
Madagascar	Sub-Saharan Africa	LIDC		UMI	LI
Mali	Sub-Saharan Africa	LIDC		LMI	LI
Nepal	South Asia	LIDC		UMI	LMI
Nicaragua	Latin America & Caribbean	LIDC		HI	LMI
Niger	Sub-Saharan Africa	LIDC		HI	LI
Pakistan	South Asia	EM		UMI	LMI
Senegal	Sub-Saharan Africa	EM		LI	LI
Tanzania	Sub-Saharan Africa	LIDC		LMI	LI
Uganda	Sub-Saharan Africa	LIDC		UMI	LI

Note:
Regarding income groups, for operational and analytical purposes, economies are divided among three groups according to the International Monetary Fund (IMF) classification. Therefore, AE, EM and LIDC stand for Advanced Economies, Emerging Market Economies and Low-Income Developing countries. The main criteria used by the IMF to classify the world into advanced economies, emerging market and developing economies are (1) per capita income level, (2) export diversification— so oil exporters that have high real per capita GDP would not make the advanced classification because around 70% of its exports are oil; and (3) degree of integration into the global financial system. As for other classifications: OECD: Organisation for Economic Cooperation and Development; EU: European Union; EMU: European Economic and Monetary Union; OPEC: Organization of the Petroleum Exporting Countries; G20: Group of twenty economies that account for around 90% of the gross world product. In relation to relative public and private indebtedness, based on public and private debt-to-GDP ratios, we have classified them as low indebted (LI), lower middle indebted (LMI), upper middle indebted (UMI), and high indebted (HI), the cut-off points between each of the groups being the first, the second and the third quartile.

Table 5 reports the results obtained by Gómez-Puig *et al.* (2022) when estimating the growth model by GFE-2SLS allowing for specific slopes by including interactions of the debt variable (d_{it}) with the group indicator variables[8]. It should be noticed that the variables *HK* and *FIN* turned out to be non-significant, so following the general principle of parsimonious data modelling, they were excluded from the final estimation.

Table 5

HETEROGENEOUS EFFECTS BY GROUPS, GFE-2SLS

lagged y	-0.0002***
	(0.0000)
Group 1*d	-0.0266***
	(0.0031)
Group 2*d	-0.0227***
	(0.0025)
Group 3*d	-0.0110***
	(0.0018)
Group 4*d	-0.0083***
	(0.0024)
Group 5*d	-0.0061***
	(0.0016)
OPEN	0.0229
	(0.0017)
INF	-0.0129***
	(0.002)
POPGR	-0.7225***
	(0.1911)
GCF	0.1075***
	(0.0212)
N	2435

Notes:

The table reports estimated coefficients from the extended model to explore the possibility of heterogeneous effects, given by equation (6), including interactions of the variable d_t with the group indicator variables.

The dependent variable is *g,* the growth rate of real *per capita* GDP. Lagged *y* is lagged real *per capita* GDP, *d* is the public debt-to-GDP ratio, *OPEN* is openness to trade, *INF* is the GDP deflator inflation rate, *POPGR* is the population growth rate and *GCF* is the ratio of gross capital formation to GDP.

Group 1, Group 2, ..., Group 5 are dummy variables that take the value 1 if the country belongs to the corresponding group or zero otherwise. See Table 4 for the list of countries belonging to each group. Robust standard errors in round brackets. Regression includes group FE, year FE and group-year FE.

*** p<0.01, ** p<0.05, * p<0.1

[8] The regression includes country fixed effects and year fixed effects. Using this specification, we rule out that the inference regarding the parameters of interest is contaminated by unobserved determinants that are constant over time (country fixed effects) or affect all countries at a given point in time in the same way (year fixed effects).

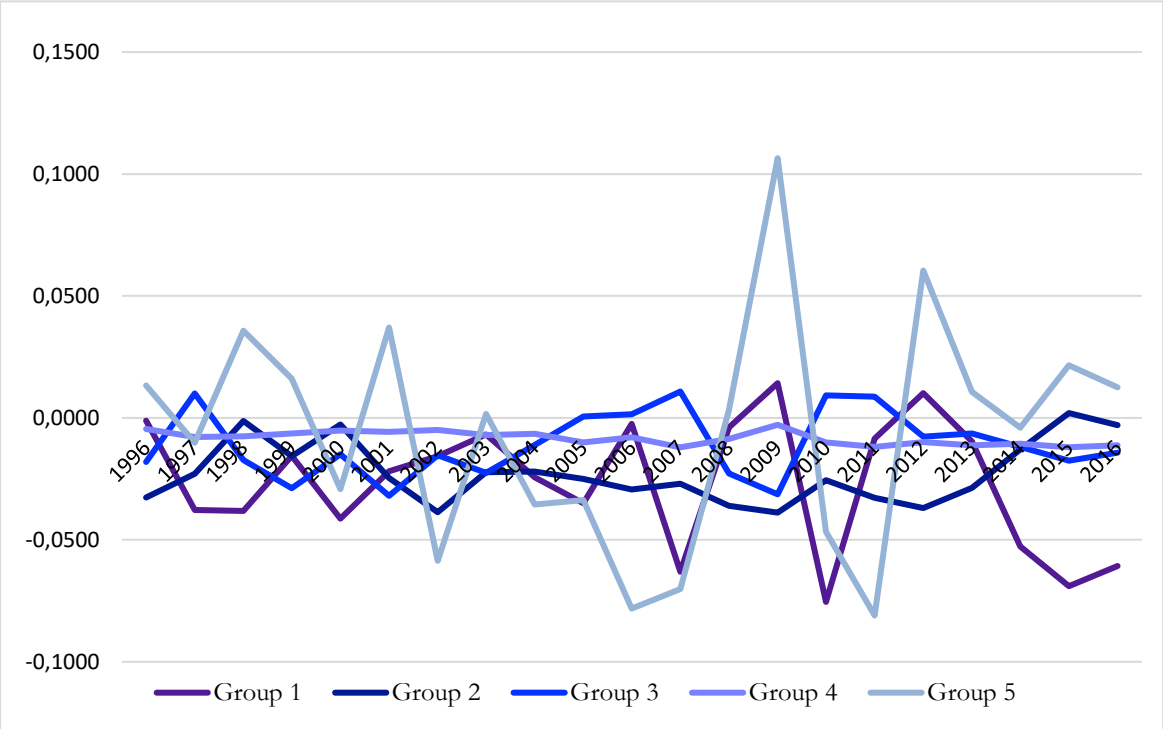
Note that, for expository convenience, In Table 5 the endogenously identified groups have named according to their estimated impact, being Group 1 the one with the highest estimated impact and Group 5 the one with the lowest estimated impact.

It can be observed that the coefficient of the interaction term is negative and significant for all groups and that the estimated impact ranges between -0.027 in Group 1 to -0.006 in Group 5. These results imply that a one standard deviation increase in the public debt-to-GDP ratio reduces the rate of growth by about 1.83 on average for Group 1, 0.84 for Group 2, 0.33 for Group 3, 0.30 for Group 4 and 0.16 for Group 5.

We proceed further by estimating the time-varying GFE model (equation 6). Figure 1 shows the evolution of the estimated coefficient of public debt-to-GDP ratio on economic growth by country groups over time. As can be seen, there is time-varying heterogeneity within and between identified country groups.

Figure 1

TIME-VARYING COEFFICIENTS OF PUBLIC DEBT-TO-GDP RATIO ON ECONOMIC GROWTH



It can be observed that, in general, the more volatile the estimated effect over time (measured by the standard deviation), the higher the impact. It is noticeable that estimated parameters are quite stable in Groups 2, 3 and 4, being Group 5 the exception as it records the highest volatility. This last feature could be related to the fact that Group 5 is mainly composed of low-income developing countries, being these economies traditionally characterized by relatively recurrent growth accelerations but nearly as frequent growth collapses, coupled with a heightened balance of payments vulnerability and debt overhang (UNCTAD, 2012). It is also noticeable that, in four

out of the five groups (1, 2, 4 and 5), the negative estimated effect of debt on economic growth reaches its maximum value (in absolute terms) during the period 2007-2011, coinciding with the Great Recession (2007-2013)[9]. The exception is Group 3, where the highest estimated effect takes place in 2001, being connected with the early 2000s recession mainly registered in developed countries. Finally, it is remarkable the occurrence of positive effects in Group 5, being especially high in 2009 and 2012.

Subsequently, to analyse the potential determinants of the identified heterogeneous dynamic group effects of public debt on growth, we run regressions of the time-varying coefficients of the impact of public debt-to-GDP ratio on economic growth by country groups (depicted in Figure 1) on their potential drivers. To overcome the problem of coefficient comparison when the variables are measured in different units, we use standardized coefficients to evaluate the relative importance of the different explanatory variables. Table 6 displays the results.

It can be seen that the variable that captures the quality of the institutions (GQI_t) has a positive significant impact in the relationship between public debt and growth in all groups, meaning that, the sounder the institutions, the less negative or the more positive the effect of a public debt increase on economic growth. This implies that GQI_t has a positive moderating effect on the relationship between public debt and economic growth, in agreement with Jalles (2011), Kourtellos *et al*. (2013), and Kim *et al*. (2017), who also found empirical evidence that the quality of governance, the control of corruption and the level of democracy are relevant factors influencing the relationship between debt and economic growth.

[9] According to EICHENGREEN *et al*. (2019), about two-thirds of the increase in the advanced-country debt ratio during the Great Recession was accounted for by the cumulative increase in the primary deficit, reflecting revenue losses and expansionary fiscal policies.

Table 6

EXPLORING DRIVERS OF TIME-VARYING COEFFICIENTS BY GROUPS

	Group 1	Group 2	Group 3	Group 4	Group 5
GQI	0.0357**	**0.1473****	**0.1427****	**0.1047****	**0.0358****
	(0.0137)	**(0.0537)**	**(0.0519)**	**(0.0383)**	**(0.0132)**
DQPD	**-0.0388*****	**-0.0351****	-0.2164	**-0.3289****	**-0.3513****
	(0.0113)	**(0.0127)**	(0.1738)	**(0.1213)**	**(0.1283)**
DQPRD	**-0.4302****	**-1.5438****	**-1.6129*****	**-0.3268****	-0.7373
	(0.1639)	**(0.5476)**	**(0.5146)**	**(0.1250)**	(0.4248)
GF01	**-0.8376****	**-1.6037****	-6.3998	**-3.1010*****	**-6.7587*****
	(0.3204)	**(0.5732)**	(5.3327)	**(0.9936)**	**(2.1226)**
GF02	**-0.4250*****	**-1.2957*****	**-0.6889*****	-0.6551	-0.2499
	(0.1316)	**(0.4343)**	**(0.2222)**	(0.6222)	(0.3874)
GF03	0.3073	**1.7905****	**0.1071*****	-0.4762	**0.6613*****
	(0.2366)	**(0.6441)**	**(0.0342)**	(0.6696)	**(0.2101)**
GF04	**0.1472****	**0.5406*****	**0.8374*****	**0.4575****	**0.9743*****
	(0.0556)	**(0.1703)**	**(0.2608)**	**(0.1717)**	**(0.3033)**
GF05	**0.1317*****	**0.1899*****	**0.0731****	0.0245	0.5038
	(0.0430)	**(0.0617)**	**(0.0262)**	(0.0211)	(0.5450)
GF06	0.2225	1.7939	**0.1634*****	**0.6396*****	**0.7227*****
	(0.2203)	(1.5405)	**(0.0525)**	**(0.2138)**	**(0.2315)**
GF07	**1.6693****	**2.9609****	1.1865	**0.9771****	**0.7310****
	(0.5077	**(0.9357)**	(0.9875)	**(0.3702)**	**(0.2680)**
GF08	**-0.4060*****	**-0.2321*****	**-0.2883****	**-0.1682*****	**-0.0865****
	(0.1298	**(0.0072)**	**(0.1030)**	**(0.0507)**	**(0.0317)**
GF09	**1.2073*****	**2.0412****	**1.0801****	**2.4472*****	**2.0118****
	(0.3842)	**(0.6552)**	**(0.3588)**	**(0.7821)**	**(0.7484)**
GF010	**1.8344****	**0.4091*****	**1.5783*****	**1.0145****	**1.7216****
	(0.6754)	**(0.1370)**	**(0.5023)**	**(0.3779)**	**(0.6438)**
STD	**-3.4046*****	**-0.8631****	**-2.8737****	**-3.5639*****	**-2.0258*****
	(1.0372)	**(0.2318)**	**(1.9596)**	**(1.1488)**	**(0.6726)**
Constant	**-0.0625****	**-0.0007*****	**-0.0170*****	**-0.0152****	**-0.2487*****
	(0.0233)	**(0.0002)**	**(0.0052)**	**(0.0056)**	**(0.0822)**
Adjusted R^2	0.6759	0.6712	0.6864	0.6124	0.6388
RMSE	2.1888	2.6551	1.8534	3.1812	2.9593

Notes: The table reports estimated coefficients from a regression of the time-varying slopes by groups depicted in Figure 1 on its postulated determinants. GQI is a government quality indicator; DQPD and DQPRD are relative public and private indebtedness, respectively; GF01 denotes expenditure on general public services; GF02 denotes expenditure on defence; GF03 denotes expenditure on public order and safety; GF04 denotes expenditure on economic affairs; GF05 denotes expenditure on environment protection; GF06 denotes expenditure on housing and community amenities; GF07 denotes expenditure on health; GF08 denotes expenditure on recreation, culture and religion; GF09 denotes expenditure on education; GF10 denotes expenditure on social protection; and STD is a proxy the short-term debt.

See Table 4 for the list of countries belonging to each group. Robust standard errors in round brackets. *** p<0.01, ** p<0.05, * p<0.1. The bold letters show the statistically significant coefficients.

The variable that gauges the relative level of public indebtedness ($DQPD_t$) registers a negative, statistically significant impact in the debt-growth nexus in all groups of countries, except for Group 3, for which this effect is negative, although not statistically significant. Interestingly, on average, the relative level of public debt is low in Groups 1 and 2, while it is high in Groups 4 and 5. These results suggest that the threshold beyond which an increase in public debt has a negative effect on economic growth differs across countries (see, e.g., Edberhardt and Presbitero (2015) or Chudik *et al*. (2017)). Specifically, this threshold is much lower in countries in Groups 1 and 2 (i.e., the room for manoeuvre for increasing public debt is very limited, even when their level of public indebtedness is low) rather than in countries in Groups 4 and 5 (where the estimated effect of debt on economic growth in much lower, although their level of public indebtedness is considerably higher).

As for the relative level of private indebtedness ($DQPRD_t$) it turns out to have a significant negative impact on the debt-growth relationship in all groups of countries, except for Group 5, in line with the results presented by Schularick and Taylor (2012) or Jordà *et al.* (2016), among others, who pointed out the negative implications of excessive private debt for growth and financial stability.

Turning to the case of the relationship of expenditure composition and the debt-growth relationship, our results reinforce the idea that the impact of a public debt increase on the economy's performance might depend on whether the public expenditure funded by government debt is productive or unproductive [see Aschauer (1989), Devarajan *et al*. (1996)]. It can be observed that, if public debt funds unproductive expenditure [$GF01_t$ (general public services), $GF02_t$ (defence), and $GF08_t$ (recreation, culture and religion)], its impact on economic growth is negative (being statistically significant in four, three and five out of five groups in the case of $GF01_t$, $GF02_t$ and $GF08_t$ respectively). However, if sovereign debt funds expenditure in some of the other seven groups into which government expenditure is divided according to the classification of the functions of government (COFOG), the impact on economic growth is positive in some groups of countries. Specifically, we find a positive and statistically positive impact on the debt-growth nexus in all country groups for the following categories of public expenditure: $GF04_t$ (economic affairs, which includes roads, railways, communication, and information systems), $GF09_t$ (education), and $GF10_t$ (social protection,). For the other four categories of public spending, we only find a statistically significant, positive effect on the debt-growth nexus in several groups of countries. In particular, a rise in $GF03_t$ (public order and security, including law courts) implies a positive, significant impact in the debt-growth relationship in countries in Groups 2, 3, and 5, while an increase a rise in $GF05_t$ (environmental protection, including sewage system operation) only implies a significant, positive impact in the debt-growth relationship in countries in Groups 1, 2 and 3 (we should recall that Groups 4 and 5 include some of the lowest-income developing countries in our sample), and in $GF07_t$ (health) is associated with a significant, positive impact in the debt-growth nexus in all detected groups of countries, except for Group 3. For $GF06_t$ (housing and community amenities), our results suggest the existence of a positive effect and statistically significant for Groups 3, 4 ad 5.

Finally, the higher the proportion of short-term debt, the more negative the impact of an increase in debt on economic growth in the five group of countries as pointed out by Fatás *et al*. (2019) (the impact being especially high in Groups 1 and 4).

6. CONCLUDING REMARKS

In this paper, we have examined the dynamic heterogeneous link between public debt and economic growth, using a global sample that comprises 115 advanced, emerging and developing economies over the period 1995-2016. To that end, we have applied an extension of the GFE method that allows for group-specific coefficients (Bonhomme and Manresa, 2015b) to explore how the behaviour of the relationship differs over time between groups of countries. In particular, the GFE accounts for unobserved time-varying heterogeneity across groups of countries in panel data models, group membership being estimated along with the other parameters in the model by minimizing the sum of squares of residuals. A two-stage least squares method is combined with the GFE estimator to address the potential endogeneity of the public debt-to-GDP ratio. In addition, we have also analysed the drivers of the detected heterogeneous dynamic impact of the public debt-to-GDP ratio on economic growth by running panel regressions to assess the relative role played by the quality of institutions, the composition of public expenditure funded with debt, the relative public indebtedness, the relative private indebtedness, and the maturity of the debt.

As in every empirical analysis, the results must be treated with some caution since they are obtained using a given set of countries over a certain period of time and based on a given econometric methodology. In this context, our findings suggest that the relationship between public debt-to-GDP ratio and growth varies across groups of countries. In particular, the GFE estimator endogenously splits the sample into five groups that show dissimilar time patterns and a different estimated impact of the public debt on economic growth (ranging from -0.027 in Group 1 to -0.006 in Group 5). When analysing the underlying variables driving the classification of countries in such groups, our results indicate that the likelihood of a strong impact is partially mitigated by the quality of a country's institutions and crucially intensified by the level of both public and private indebtedness and the maturity of the debt. The type of expenditure that is funded with debt is also detected as an important influence in the heterogeneous relationship between public debt and economic growth (negatively in the case of unproductive spending, and positively in the case of productive spending). These results not only identify relevant factors that help to explain the debt-growth nexus, but also provide some insights concerning the empirical quantification and characterization of the heterogeneity of the relationship across groups of countries.

Regarding policy implications, our results indicate that the nexus between the public debt-to-GDP ratio and economic growth differs by groups of countries and is crucially related to the diversity and quality of the institutions and public policies that make up the socio-economic environment. Our findings suggest that controlling corruption and promoting government effectiveness and the rule of law could contribute to restrain the adverse effects of public debt on economic growth. Our results also support the rationale of issuing long-term debt and increasing the fraction of outstanding long-term debt since our findings imply that short-term debt could be a fundamental

source of financial fragility, further negatively affecting the debt-growth relationship. Finally, we also document the need of a serious scrutiny of the composition of expenditure to improve the economic performance and to a higher steady-state growth rate.

Our results have practical implications for national policymakers and international organizations responsible for global economic surveillance and might shed some light regarding the potential effects that the expansionary measures to contain the health and economic crisis related to the coronavirus pandemic in 2020 might have in the different countries' rate of growth.

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