On the heterogeneous link between public debt and economic growth

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Abstract

We use panel data for 115 countries over 1995-2016 to model the heterogeneity of the debt-growth nexus along with the underlying factors that might explain it. The grouped fixed effects (GFE) is used to endogenously classify countries into groups and a multinomial logit model is utilized to explore the drivers of the heterogeneity. The GFE estimator classifies countries into five groups with different impact of debt on growth. The likelihood of a strong impact is moderated by the institutions' quality and the proportion of productive expenditure but intensified by the level of indebtedness and the maturity of the debt.

Keywords: Public debt; Economic growth; Heterogeneity; Grouped fixed effects; Panel data; Multinomial logit regression.

JEL Classification Codes: C23, F33, H63, O47, O52

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1. Introduction

In 2020, amid the fourth wave of global debt (see World Bank, 2020), the largest one-year debt surge since World War II took place, with global debt rising to $226 trillion as the world was hit by a global health crisis and a deep recession. Concretely, global debt rose by 28 percentage points to 256 percent of GDP according to the latest update of the International Monetary Fund's Global Debt Database[1]. 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 while private debt from non-financial corporations and households also reached new highs. Therefore, this was a broad-based phenomenon, with government, private, domestic, and external debt all at multi-decade highs in advanced countries, emerging market and developing economies alike. While in advanced economies, total debt reached 300 percent of GDP in 2020 in emerging market and developing economies, total debt reached 206 of GDP. Moreover, government reached more than 120 and 60 percent of GDP in advanced economies, and in emerging market and developing countries, respectively (see Kose *et al.*, 2021).

In this scenario, the empirical study of the nexus between public debt and economic growth, a traditional focus of study for economists, has become an issue of paramount importance. Therefore, this paper by using panel data for 115 countries over 1995- 2016 aims to contribute to the existing empirical literature in two respects. We first use a data-driven procedure to group countries endogenously: the grouped fixed effects (GFE) estimator, recently proposed by Bonhomme and Manresa (2015). To the best of our knowledge, this is the first paper to apply the GFE methodology to examine whether the debt-growth relationship differs across groups of countries, with the pattern of heterogeneity being endogenously determined by the data[2]. The

[1] Global debt reached 228 per cent of GDP in 2019 and government debt 83 per cent of GDP. See https://blogs.imf.org/2021/12/15/global-debt-reaches-a-record-226-trillion/.

[2] The GFE estimator considers 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. Furthermore, the GFE estimator arguably deals better than other estimators with endogeneity due to unobserved heterogeneity.

second contribution of this paper is to analyse the drivers of the detected heterogeneous impact of debt on economic growth, making use of a multinomial logit regression model to 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 paper aims to fill these two gaps in the literature by focusing on a panel-data sample of 115 countries over the period 1995-2016 to provide greater insights on the heterogeneous impact of government indebtedness on economic growth.

Concretely, the existing literature has grouped studies into two main strands (see Mitze and Matz, 2015). The "first generation" strand includes the works by Reinhart and Rogoff (2010), Pattillo *et al.*, (2011), Lof and Malinen (2014) and Woo and Kumar (2015), among others[3]. This strand focused mainly on the nonlinear effects in the debt-growth relationship and predicted an inverted U-shape relationship between the two variables (debt begins to harm economic growth when the debt-to-GDP ratio exceeds a certain threshold – 90%, according to the seminal paper by Reinhart and Rogoff (2010)). While the results tend to vary depending on the econometric methods, specifications and samples (countries and periods), most of the studies in this strand conclude that public debt hinders economic growth indicating that countries mainly are in the downward-sloping part of the inverted U, being the magnitude of the effect similar among the studies –in the range 0.01-0.02 percentage points less growth linked to one percentage point rise in debt-to-GDP ratio–, as highlighted by Woo and Kumar (2015).

The "second generation" strand goes beyond the nonlinearities in the relationship and focuses instead on the heterogeneity of debt-growth nexuses across countries [Ghosh *et al.* (2013), Pescatori *et al.* (2014), Edberhardt and Presbitero (2015), Markus and Rainer (2016), Chudik *et*

[3] The empirical literature examines different samples of countries and periods, and most of them confirm the negative relationship between high debt and growth [Reinhart and Rogoff (2010)' analysis uses a sample of 44 countries for about 200 years; Patillo (2011) focuses on 93 developing countries for 1969-98; Lof and Malinen (2014) analyze 20 developed countries for 1954-2008 and Woo and Kumar (2015) use 38 advanced and emerging economies during 1978-2008].

al. (2017), Chiu and Lee (2017) and Gómez-Puig and Sosvilla-Rivero (2017, 2018)][4]. The studies in the second strand acknowledge that the effects of public debt on growth may vary depending on country-specific macroeconomic, financial, and institutional variables. Chudik *et al.* (2017) report that there are significant negative long-run effects –irrespective of whether threshold variables are included in the model– ranging between -0.03 and -0.15.

In this context, our paper belongs to the above-mentioned "second generation" of studies and, although we do not underestimate the potential existence of nonlinearity in the debt-growth relationship, our goal is to investigate and quantify the heterogeneity of the debt-growth nexus along with the underlying factors that might explain it globally.

To our knowledge, and possibly due to its complexity, no paper has analysed simultaneously the two issues (nonlinearity and heterogeneity) that concern the debt-growth relationship. For instance, Chudik *et al.* (2017) acknowledge that relaxing the homogeneity assumption is difficult when it comes to the estimation of country-specific thresholds, because due to the nonlinearity of the relationships, identification and estimation of country-specific thresholds require much larger time series data than those available. They therefore follow an intermediate approach testing for the threshold effects not only for the full sample of 40 countries but also for two subsamples (advanced economies and developing countries), assuming homogeneous thresholds within each subgroup. While Eberhardt and Presbitero (2015) introduce non-linearities at the country level in the debt-growth nexus by selecting "exogenously" given thresholds (they focus on 60%, the sample mean, and the popular 90% debt-to-GDP ratio) which allow them to investigate heterogeneous growth regimes (below and above the threshold) while accounting for

[4] Again, the empirical literature examines different samples of countries and periods [Gosh *et al.* (2013) focused on 23 advanced economies for 1970-2007; Eberhardt and Presbitero (2015) on 118 countries for 1961-2012; Markus and Rainer on 111 OECD and developing countries for 1971-2010; Chudik *et al.* (2017) on 40 countries over the 1965-2010 period; Chiu and Lee covered 61 countries for 1985-2009. Finally, Gómez-Puig and Sosvilla Rivero (2017) focused on the relationship between sovereign debt and growth in 11 euro-area countries for 1961-2015, whilst Gómez-Puig and Sosvilla-Rivero (2018) analyzed the effects of all sources of nonfinancial debt (household, corporate as well as government) on economic growth in ten euro-area countries for 1980-2015. While the results vary depending on the methods, specifications and samples (countries and periods), all of them suggest that there is no evidence for a similar, let alone common, relationship between debt and growth across countries.

cross-sectional dependence. Due to these computational constraints and given the relatively small sample available, we chose to focus on the "heterogeneity" issue, since it is very relevant and has not yet received as much attention as the "non-linearity" issue in the literature[5].

The main results of our study show that the relationship between public debt and growth does vary across groups of countries. In particular, the GFE estimator endogenously splits the sample into five groups of countries that have dissimilar time patterns and a different estimated impact of public debt on economic growth (ranging between -0.027 and -0.006). When analysing the variables driving the different impacts, our results indicate that the likelihood of a strong impact is moderated by the quality of a country's institutions and the proportion of productive expenditure but intensified by the level of indebtedness and the maturity of the debt.

The rest of the paper is organized as follows. Section 2 presents the rationale for our empirical approach based on the results of some preliminary descriptive analyses. Section 3 introduces the analytical framework. Section 4 describes the data used in the analysis. The econometric methodology is explained in Section 5. Empirical results are presented in Section 6. Finally, some concluding remarks and policy implications are offered in Section 7.

2. Descriptive analysis

In what follows, we provide some descriptive analyses highlighting the cross-country heterogeneity in the evolution of sovereign debt-to-GDP ratio in the 115 countries in our sample (see Table 1) over the period 1995-2016. Figure 1 shows the evolution of the average debt ratio in three groups of countries following the International Monetary Fund (IMF) classification: advanced economies (AE), emerging market economies (EM), and low-income developing countries (LIDC).

[Insert Table 1 here]

[Insert Figure 1 here]

[5] Nonetheless, we have also estimated our model with a quadratic term in debt to capture non-linearities but did not find significant results. Those are available from the authors upon request.

We can observe that, from the outbreak of the global financial crisis (2008-09) until the end of the sample period in 2016, on average, government debt has risen by over 20% of GDP in advanced economies and by around 13% of GDP in emerging markets [see Bredenkamp *et al.*, 2019 and Yared (2019)], whilst in low-income developing countries (with only a few exceptions) new debt accumulation was contained during the crisis, thanks largely to the debt relief efforts of the late-1990s and early 2000s[6] (see Eichengreen *et al.*, 2019) and did not experience an increase until 2012 (on average, 14% of GDP), coinciding with the fourth wave of debt (see World Bank, 2020). These increases have given rise to average public debt-to-GDP ratios of around 75% in advanced economies, 54% in emerging markets and 56% in developing countries by the end of 2016.

However, as public debt increases are far from being homogeneous within the three groups of countries, the debt-to-GDP ratios are highly dispersed in the different groups over the sample period. More specifically, despite their relatively moderate average values at the end of 2016, debt-to-GDP ratios registered values above 100% in eight advanced economies and above 90% in three. Moreover, two emerging market and four low-income developing countries were also above 100%. For instance, Japan registered the highest government debt (not only in our sample but also in the world) at 236% of its GDP in 2016. It was followed in the ranking by Greece, still recovering from the effects of its economic crisis and subsequent bailout, at 183%. It is noticeable that five euro-area countries also registered ratios above or close to 100% in 2016: Italy, Portugal, Belgium, Spain, and France. Finally, several Caribbean and African countries also had high national debts in the same year, including Barbados, Jamaica, Belize, The Republic of Congo, Cape Verde, Mauritania, Sudan, and Egypt.

Among the world's major economic powers, the United States registered the highest national debt at 107% of its GDP in 2016. China, the world's second-largest economy and home to the

[6] The Heavily Indebted Poor Countries (HIPC) initiative and the associated Multilateral Debt Relief Initiative (MDRI) explain these figures since recipient countries were required to establish a track record of strong policy performance under IMF and World Bank supported programs before receiving large write-downs of both official bilateral and multilateral debt.

world's largest population, had a public debt ratio of just 44% of its GDP in 2016 –even though, since the onset of the Global Financial Crisis, the country accounts for almost three-quarters of the increase in global private nonfinancial debt, which represents over 200% of its GDP (see Bredenkamp *et al.*, 2019). Among the 115 countries in our sample, Germany, Europe's largest economy, also had a relatively low sovereign debt ratio at 68%, whereas at the other end of the ranking, Estonia registered the lowest ratio in 2016 (9%), followed by three sub-Saharan African countries: Botswana, Congo Democratic Republic and Nigeria (with ratios that ranged between 15% and 20%).

All in all, the above figures indicate that the evolution of the public ratio of indebtedness presents very different patterns, not only across the 115 countries in our sample, but also within each of the three groups of countries of the IMF income-based classification. We claim that the use of the GFE methodology, which leaves group membership unrestricted rather than imposing it *ex-ante*, represents a more useful tool for capturing those heterogeneities. Moreover, the endogenous classification of countries would allow us to examine whether the differences in the relationship between debt and economic growth depend on factors others than *per capita* income, such as the institutional environment, the composition of debt-funded public expenditure, the relative ratio of private and public indebtedness, or debt maturity.

3. Analytical framework

3.1. The debt-growth relationship

Following Gómez-Puig and Sosvilla-Rivero (2017 and 2018)[7], to examine the debt-growth relationship we make use of an empirical growth model derived from the neoclassical growth

[7] Gómez-Puig and Sosvilla-Rivero (2017 and 2018) examined the heterogeneity in the public debt-economic growth nexus in EMU countries by means of time-series techniques and allowing for complete individual heterogeneity. However, single-country estimations may be rather inefficient since they do not make use of cross-section information and the approach fails to capture any common patterns. Therefore, since it is very important not only to impose some structure on individual heterogeneity but also to allow for different relationships within the sample, the grouped fixed effect (GFE) estimator seems well suited for the purposes of this paper.

theory. We consider 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_{it}) is given by:

$$g_{it} = \alpha + \gamma y_{it-1} + \sum_{j=1}^{n} \delta_{ij} X_{ijt} + \beta d_{it} + \varepsilon_{it} \qquad (1)$$

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_{it} is the public debt-to-GDP ratio, and ε_{it} denotes the error term.

Regarding X_{it}, we consider a set of explanatory variables that are consistently associated with growth in the literature [see, e.g., Aghion and Howitt (2009) or Sachs and Warner (1997)]. Our model includes population growth rate as a percentage (*POPGR*); the ratio of gross capital formation to GDP (*GCF*); life expectancy at birth, a proxy for the level of human capital (*HK*); openness to trade, measured by the sum of exports and imports over GDP (*OPEN*); the GDP deflator inflation rate, a measure of macroeconomic instability and uncertainty (*INF*); the long-term interest rate as an indicator of debt sustainability (*INT*); the unemployment rate as a variable capturing the country's growth potential and the macroeconomic environment (*UNEM*); and a traditional indicator of financial depth (*FIN*) [8].

In the economic growth literature, the rate of growth of labour used in the production process and the accumulation of physical capital (investment) are the key determinants of growth (Solow (1956) and Frankel (1962), among others). Therefore, population growth (*POPGR*) and the ratio of gross fixed capital formation to real GDP (*GCF*) are used to proxy country size and the rate of labour growth and the accumulation of the physical capital stock respectively.

A proxy of human capital (*HK*) is included to reflect that countries with an abundance of human capital are more likely to be able to attract investors, absorb ideas from the rest of the world, and engage in innovation activities (Grossman and Helpman, 1991). Trade openness (*OPEN*) is

[8] We are grateful to an anonymous referee for suggesting the use of variables capturing the broad macroeconomic and monetary environment.

posited to boost productivity through transfers of knowledge and efficiency gains (Seghezza and Baldwin, 2008). Regarding the inflation rate (*INF*), it has been argued that inflation is a good macroeconomic indicator of how the government manages the economy [see Fischer (1993) or Barro (2003), among other authors] and that low inflation brings about economic efficiency because, through the price mechanism, economies can allocate scarce resources to their best economic use (World Bank, 1990). About the long-term interest rate (*INT*), most papers analysing the investment channel show that the relationship between interest rates and output is negative [see, e.g., Haavelmo (1960), Tobin (1965) or Kydland and Prescott (1982) among others]. Recent contributions from Brunnermeier *et al.* (2021) and Blanchard (2021) suggest that its trajectory have important implications for debt sustainability, and it affects GDP through this channel[9]. With respect to the unemployment rate (*UNEM*), Okun's law (1962) postulates a negative relationship between movements of the unemployment rate and the real GDP by focussing on the empirical relationship between unemployment and GDP variations. This relationship is among the most famous in macroeconomics theory (Blinder, 1997) and has been found to hold for several countries and regions, mainly in developed countries [see, e. g., Tatom (1979), Lee (2000) and Gil-Alana (2010)]. Finally, given that the financial markets are likely to influence the levels of debt that can be sustained without negative impacts, we also introduce the ratio of liquid liabilities to GDP (*FIN*) as an indicator of financial development, following King and Levine (1993) and Beck *et al.* (2000). In particular, (*FIN*) 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).

[9] Note also that Canzoneri *et al.* (2002) and Laubach (2009), among others, present evidence on the interest rate effects on expected deficits and debt.

3.2. The potential drivers of the heterogeneous debt-growth relationship

Once a heterogeneous debt-growth relationship is found using equation (1), we explore the potential drivers of the detected heterogeneity. To that end, based on a selective review of the empirical and theoretical literature, we take an eclectic approach and consider variables that measure the quality of institutions, the relative public and private indebtedness, the debt maturity, and the composition of public expenditure as potential drivers for the characterisation of the identified groups of countries.

About the quality of institutions (*GQI*), the role of sound and efficient institutions in explaining long-run growth was formalized in several contributions in the early 2000s, which showed that countries with weaker institutions find it harder to sustain growth and are more vulnerable to experiencing periods of crisis and stagnation (see Acemoglu *et al.* 2001, 2002, 2005a and 2005b). However, the role played by institutions in explaining the relationship between debt and growth has mostly been ignored. To the best of our knowledge, the exceptions are Jalles (2011), Kourtellos *et al.* (2013), and Kim *et al.* (2017) who find empirical evidence suggesting that the quality of governance, the control of corruption and the level of democracy are relevant. We rely on the definition of economic institutions proposed by Acemoglu *et al.* (2005a) where good economic institutions are the ones providing security of property rights and relatively equal access to economic resources to a broad cross-section of society. Yet, since measuring the quality of institutions is a challenging task, it is common practice in the literature to measure it in terms of perceptions, which may not necessarily reflect the quality of the law but rather the actual workings of the economy. For this reason, to capture differences in the quality of country governance, we use the World Bank's Worldwide Governance Indicator (WGI), which offers better time-variant characteristics than other governance measures.

Turning to the case of the private debt (*PRDEBT*), we should recall that according to the Global Debt Database published by the IMF, of the global total debt at the end of 2020, 60 percent was nonfinancial private debt (debt held by households and nonfinancial corporations). Nonetheless,

while the unprecedented increase in public debt and its scale have raised serious concerns among economists, they have taken a more nuanced position on 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]. However, all forms of debt, when they are high and moving upwards, are sources of justifiable concern. Regarding the negative implications of excessive private debt (a "debt overhang") for growth, some authors [see, e.g., Schularick and Taylor (2012) and Jordà *et al.* (2016)] have shown that high debt levels in the private sector are not only a good predictor of financial crises, but also a key determinant of the intensity of the ensuing recession.

Concerning the debt maturity variable, Fatás *et al.* (2019) stated that one of the reasons why it is difficult to identify common patterns and to pin down the causal effect of debt on growth is that not all debts are equal; factors such as debt maturity are key elements that can affect fiscal vulnerabilities and the responses of governments to debt changes. Therefore, as a proxy of debt maturity, we have introduced short-term debt expressed as a percentage of total external debt (*STD*).

Finally, regarding the role of government expenditure composition, no empirical paper has examined to date the effect of this variable in the debt-growth nexus, despite its relevance and the fact that several authors referred to it. For instance, Devarajan *et al.* (1996) and Aschauer (1989) 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. While the former, which includes physical infrastructure (roads and railways), communication, information systems (phone, internet), education or health, may have a positive impact on the growth rate of the economy, the latter does not affect the economy's long-run performance, although it may have positive short-run implications. In this regard, Kneller *et al.* (1999) show that productive government spending influences private sector productivity and hence has a direct impact on growth, while non-productive expenditure, which normally affects citizens' welfare, is likely to have a zero or negative growth impact.

4. Data

We use annual data for 115 countries –including advanced economies, emerging market economies and low-income developing countries– over the period 1995-2016.

Although growth is generally defined over much longer periods, our sample size is limited due to data availability. In particular, the data for the relevant variable (*d*, the debt-to-GDP ratio) is only available from a homogeneous source starting in 1995; whereas 2016 is the last year for which the data for the traditional indicator of financial depth *(FIN*) is available[10]. Moreover, we follow the general to specific approach based on the theory of reduction (Hendry, 1995, ch. 9). Therefore, our empirical analysis starts with a general statistical model that captures the essential characteristics of the underlying dataset, reducing the complexity of this general model by eliminating statistically insignificant variables, checking the validity of the reductions at every stage to ensure congruence of the finally selected model always using the same dataset.

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 main 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* GDP at 2010 market prices, 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 debt-growth relationship.

[10] Even if we would have removed the *FIN* variable from the model, the longest we could extend the sample would be four years, that is, until 2020, which still would not allow us to assess the effects of the crisis caused by the COVID pandemic (it would only include the first year of the health crisis and its effects would be diluted in the analysis which is based on average impacts). So, we opted by keeping the *FIN* variable in the model and therefore estimate it for the period 1995-2016.

[Insert Table 2 here]

[Insert Table 3 here]

Regarding our proxy of the quality of institutions (*GQI*), we use the WGI index. This index covers six broad dimensions of governance for over 200 countries since 1996 and summarizes views on the quality of country governance provided by several survey organizations, non-governmental organizations, commercial business information providers, and public sector organizations worldwide. It follows the methodology of Kaufmann *et al.* (2010) and is updated annually by the World Bank. 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. We have selected the last four indicators[11], which capture the quality of economic and administrative institutions (the definitions are presented in Table 3). Following Chong and Gradstein (2007) and Beltratti and Stulz (2012) we take the simple average of these four components 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*) in our analysis).

Data regarding private debt (*PRDEBT*) have been drawn from the Global Debt Database. This database offers the total gross debt of the (private and public) nonfinancial sector for an unbalanced panel of 190 countries (see Mbaye *et al.*, 2018), including the 115 countries of our sample. We have selected the variable total private debt as a percentage of GDP[12]. 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

[11] Following Helliwell *et al.* (2014) the six composite measures reported by the World Bank are divided into two groups and only the average of the second group of indicators (which contains four measures primarily concerned with the quality of the delivery of government services: government effectiveness, regulatory quality, rule of law, and the control of corruption) is included in our analysis. The first group of two indicators measures the state of democracy and other aspects of the electoral process (voice and accountability, and political stability and absence of violence).

[12] See Table 3 for an explanation of private debt calculation.

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*) and (*DQPRD*), 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. As a proxy of debt maturity, we used short-term debt expressed as a percentage of total external debt (*STD*) from the World Bank's World Development Indicators and from the Coordinated Portfolio Investment Survey (CPIS) database provided by the IMF.

Finally, with respect to the government expenditure composition, the International Monetary Fund Government Financial Statistics was the source used to construct this variable. This dataset, usually known as the classification of the functions of government (COFOG), divides government expenditure into 10 categories. 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 ($PROEXP_t$), including general public services *(GF01)*, defence *(GF02)*, economic affairs *(GF04)* –it includes transport and communication–, housing and community amenities *(GF06),* health *(GF07)* and education *(GF09)*, and unproductive expenditures ($UNPROEXP_t$ which encompasses public order and safety *(GF03)*, environment protection *(GF05)*, recreation, culture and religion *(GF08)* and social protection *(GF10))*[13].

To produce a data matrix without missing values, we apply two complementar5y procedures. The first one is 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. The second procedure is the simultaneous nearest-neighbour predictors proposed by Fernandez-Rodriguez *et al.* (1999), which infers omitted values from patterns detected in other simultaneous time series.

[13] 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.

5. Econometric Methodology

5.1. Exploring heterogeneous effects

Given the relatively small sample available, we use panel data econometrics to combine the power of cross-section averaging with all the subtleties of temporal dependence (see Baltagi, 2008).

To estimate model (1), we first consider two basic panel regression methods. The first one is the pooled-OLS and is based on the following assumptions about unobserved terms:

- α_i is uncorrelated with X_{it} : $E(X_{it}\alpha_i) = 0$
- $X_{it} = (y_{it-1}, INF_{it}, HK_{it}, OPEN_{it}, POPGR_{it}, GCF_{it}, INT_{it}, UNEM_{it}, FIN_{it})$
- $E(X_{it}\varepsilon_{it}) = 0$ (X_{it} predetermined)

In this first estimation method, the data for different countries are pooled together and the equation is estimated by ordinary least squares (OLS).

The second method is the fixed effects two-stage least squares (FE-2SLS), based on the following assumptions about unobserved terms (α_i and ε_{it}):

- α_i is freely correlated with
- $X_{it} = (y_{it-1}, INF_{it}, HK_{it}, OPEN_{it}, POPGR_{it}, GCF_{it}, INT_{it}, UNEM_{it}, FIN_{it})$
- $E(X_{it}\varepsilon_{is}) = 0$ for s=1, …, T (strict exogeneity) and $E(d_{it}\varepsilon_{is}) \neq\neq 0$

Therefore, this second estimation method accounts for differences between countries and the constant terms α_i are allowed to vary between them. These constant terms stand for all unobserved aspects that distinguish the countries from each other (i.e., they capture country heterogeneity). In addition, controlling for the possible endogeneity of the public debt-to-GDP ratio, the FE-2SLS estimator applies the within transformation and uses the lagged exogenous variables as instruments. Semykina and Wooldridge (2010) suggest the use of the FE-2SLS estimator, as it is robust to any type of correlation between unobserved effects and explanatory and instrumental variables, does not require specification of the reduced form equations for endogenous variables, and makes no assumptions of errors distribution.

Although we first apply standard panel data techniques with comparative purposes, the originality of the analysis in this paper arises from modelling the potential heterogeneous effects of public debt on economic growth, accounting for both varying and unvarying heterogeneity between countries using the Grouped Fixed Effect (GFE) approach, proposed by Bonhomme and Manresa (2015)[14]. 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. As said, the most appealing feature of this approach is that group membership is left unrestricted. The estimator is suitable for *N* big and *T* small and it is consistent since both dimensions of the panel tend to infinity.

In contrast to the time-invariant fixed-effects methodology, the most common approach to model unobserved heterogeneity in panel data, that is sometimes subject to poorly estimated elasticities (when there are errors in the data or when the explanatory variables vary slowly over time) and is restrictive in that unobserved heterogeneity is assumed to be constant over time, the GFE introduces clustered time patterns of unobserved heterogeneity that are common within groups of countries overcoming the above mentioned problems. 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.

Our benchmark specification is a linear model that explains economic growth, g_{it}, with grouped patterns of heterogeneity and takes the form:

[14] This estimator has been used in Grunewald *et al.* (2017) to investigate the relationship between inequality and carbon dioxide emissions and by Oberlander *et al.* (2017) to assess the distinct effects of social globalization and trade openness on national trends in markers of diet quality.

$$g_{it} = z_{it}^{'}\theta_{g_{r_i}} + \alpha_{g_{r_i}t} + \vartheta_{it}, \text{i=1,...,N, t=1,...,T} \qquad (2)$$

where $g_{r_i} \in [1,...,G]$ 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 $\alpha_{g_{r_i}}$. 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.

The model can be easily modified to allow for additive time-invariant fixed effects, which is our preferred specification[15]. We apply the within transformation to the dependent and independent variables and estimate the model with variables in deviations with respect to the within-mean. The new transformed variables are denoted as $\ddot{g}_{it} = g_{it} - \overline{g}_t, \ddot{z}_{it} = z_{it} - \overline{z}_t$, and $\ddot{\alpha}_{g_{r_i}t} = \alpha_{g_{r_i}t} - \overline{\alpha}_{g_r t}$ and the GFE in equation (2) is the outcome of the minimization of the following expression:

$$(\hat{\theta}, \hat{\alpha}, \hat{\gamma}) = \underset{(\beta,\alpha,\gamma)\in\Theta^G x \mathrm{A}^{TG} x \Gamma_G}{\arg\min} \sum_{i=1}^{N}\sum_{t=1}^{T}(\ddot{g}_{it} - \ddot{z}_{it}^{'}\theta_{g_{r_i}} - \ddot{\alpha}_{g_{r_i}t})^2, \qquad (3)$$

where the minimum is taken over all possible groupings $\gamma = (g_{r_1},...,g_{rN})$ of the N units into G groups, common parameters θ and group-specific time effects α.

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:

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

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

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

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

where $\hat{g}_{r_i}(\hat{\theta},\hat{\alpha})$ is given by (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[16].

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.

Summing up, in contrast to the country fixed effects estimator, the GFE estimator can control for unobservable time-varying country characteristics that follow a group-specific time pattern. This is particularly suitable to model the debt-growth relationship, given that the related literature has identified distinct growth paths and that the classification of countries into groups according to their level of development does not perfectly account for the underlying heterogeneity inherent in the relationship. The main identifying assumption is that the number of distinct time patterns of unobserved heterogeneity is equal to the number of groups. In other words, all countries must follow one of the group-specific time-varying paths of unobserved heterogeneity.

[16] Very similar results were obtained using the second procedure.

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 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 $j = 1, \ldots, J$. 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:

$$g_{it} = \phi y_{it-1} + \delta_1 INF_{it} + \delta_2 HK_{it} + \delta_3 OPEN_{it} + \delta_4 POPGR_{it} + \delta_5 GCF_{it} + \delta_6 INT_{it} + \delta_7 UNEM_{it} + \delta_8 FIN_{it} + \beta d_{it} + \alpha_{j_i t} + \varepsilon_{it} \quad (6)$$

where $\alpha_{j_i t}$ 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, to control for the possible endogeneity of the public debt-to-GDP ratio, equation (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.

5.2. Explaining group membership

In a second step, we implement a set of multinomial models to study the determinants of countries allocation to the categories identified by the GFE estimator [see, e. g., Greene (2012) or Hosmer *et al.* (2013)]. Specifically, we model the probability that country i is assigned to a group j as:

$$P_{ij} = \frac{e^{x_i' \beta_j}}{\sum_{k=1}^{m} e^{x_i' \beta_k}} \quad (7)$$

where $j = 1, 2, 3, \ldots, J$ corresponds to identified groups ordered by its relative impact of public debt on economic growth. To focus on the allocation into categories, we use the group of the estimated lowest impact as the (excluded) base category, therefore normalizing β_1 to zero. As

previously mentioned, the vector of country-specific characteristics x_i includes the quality of institutions, the composition of public expenditure, the relative ratio of private debt indebtedness, the relative ratio of public debt indebtedness and debt maturity. Estimation is by maximum likelihood. The assumption of independence of irrelevant alternatives is not a major issue here, because all alternatives are tied together (that is, they are meaningful only if the others exist).

Note that the correct interpretation of the coefficient estimates is that a positive/negative coefficient on a variable implies that the ratio of the probability of outcome *j*, to the probability of the chosen base outcome, increases/decreases with an increase in the value of the explanatory variable.

6. Empirical Results

6.1. Heterogeneous debt-growth relationship[17]

Table 4 reports the results obtained estimating the growth model by OLS, FE-2SLS, GFE and GFE-2SLS[18]. Recall that unlike OLS, the FE-2SLS estimation method controls for individual effects and endogeneity of regressors, the GFE method controls for individual effects and correlated unobserved heterogeneity, and that the GFE-2SLS method controls for individual effects, correlated unobserved heterogeneity and correlated unobserved heterogeneity. It should be noticed that the variables *HK*, *INT*, *UNEM* and *FIN* turned out to be non-significant, so following the general principle of parsimonious data modelling (see, e. g., Haavelmo, 1944, 74-75), they were excluded from the final estimation[19].

[17] In each model, we focus our comments on the public debt to investigate its effect on growth, summarizing the results by pointing out the main regularities. The reader should browse through Table 4 for a detailed account of the impact of other explanatory variables on the growth rate.

[18] We performed a variety of unit root tests in panel datasets to assess the time-series properties of the variables under study, being the results of the tests available upon request from the authors. But for both statistical (these tests have notorious poor power and they do not handle the possible breaks and cross-sectional dependence) and economic reasons (to compare the results with previous estimations of empirical growth models), we have estimated the growth model with the explanatory variables in levels to assess the impact of public debt-to-GDP ratio on growth controlling for the usual potential determinants.

[19] The results including these variables are available from the authors upon request. We have excluded them because models with fewer parameters are easier to interpret, understand and explain. Moreover, the estimated parsimonious model shown in Table 4 has more predictive ability than the model that includes these no-statistically significant variables.

As can be seen in Table 4, the growth rate of real *per capita* GDP is negatively associated with the public debt-to-GDP ratio. Compared to the OLS specification, the coefficient of the public debt-to-GDP ratio shrinks slightly in magnitude in all the other estimations but remains statistically significant. An additional point on public debt-to-GDP ratio is associated with a reduction in the growth rate by 0.014 in the GFE-2SLS estimation, which is our preferred estimator since it accounts for the endogeneity of regressors in the primary equation, as well as correlated unobserved heterogeneity[20]. A one standard deviation increase (37.18) in the public debt-to-GDP ratio reduces the rate of growth by about 0.50 on average, equivalent to a decrease of about 22%[21].

It is noticeable that the values of the objective function (the Bayesian information criterion, BIC) of the GFE and GFE-2SLS estimation are lower than the values of the objective function of the OLS, FE-2SLS estimation, suggesting that some cross-country heterogeneity is time-varying in our sample and justifying the appropriate use of the GFE-2SLS estimator[22].

[Insert Table 4 here]

The GFE-2SLS model uses five groups (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 5[23].

[Insert Figure 2 here]

[Insert Table 5 here]

Next, to investigate whether the public debt-to-GDP ratio has a different effect on the rate of growth in different groups, we estimated the model allowing for specific slopes by including

[20] To ascertain the relevance of the chosen instruments, we use the first-stage F-statistics proposed by Stock *et al.* (2002), obtaining a high F-statistic, which indicate that the chosen instruments are not weak and can be considered in the 2SLS. Furthermore, the results of the Sargan's (1958) and Basmann's (1960) test for overidentifying restrictions suggest non-rejection of the overidentifying restrictions, supporting the exogeneity of the chosen instrument.

[21] The mean rate of growth during the sample period is 2.24, being 0.50 the 22% of it.

[22] Following the suggestion of an anonymous referee, we tried to assess whether the Global Financial Crisis represented a structural break during the estimation period splitting the sample in two, before and after 2008, since it affected countries differently, within and (particularly) across the groups identified, Unfortunately, the number of years available for the last period, is very low, which prevents the application of the GFE estimation method.

[23] The codes used in this paper can be obtained from the authors upon request.

interactions of the debt variable (d_{it}) with the group indicator variables. Table 6 presents the impact of the debt-to-GDP ratio on real *per capita* GDP growth for each of the five groups in the sample. Note that, for expository convenience, we have named the endogenously identified groups 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.

[Insert Table 6 here]

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.

Group 1 comprises 18 countries, all of them emerging market (EM) economies except for four who are low income developing countries (Cape Verde, Congo Republic, Nigeria, and Guyana). Group 2 encompasses 28 countries, the majority of which are EM economies except for six which are advanced economies (four economies that belong to the European Monetary Union (EMU) –Estonia, Lithuania, the Slovak Republic, and Latvia– and two East Asia and Pacific (EAP) countries –Singapore and the Korea Republic–). With 40 countries, Group 3 is the largest and includes the richest economies. Most of the countries are advanced economies (AE) that belong to the OECD (14 euro-area members, 7 European countries outside the euro jointly with Canada, the United States, Japan, New Zealand, and Israel) and the other 14 are EM economies (Saudi Arabia, Brazil, Argentina, or South Africa among them). Finally, two- thirds of the economies in Groups 4 and 5 (they present the lower impact of debt on economic growth) are Sub-Saharan Africa low income developing countries (LIDC). Group 4 is composed of 10 countries that are LIDC except for India and the Philippines (EM economies), whilst Group 5 encompasses 19 LIDC except for Nepal, Pakistan and Senegal which are also EM economies.

Regarding the public debt-to-GDP ratio, Group 1 is mainly made up of highly indebted countries –in the highest 25% of the whole sample– while in Group 2 predominantly low indebted countries – in the lowest 25% of the whole sample– are placed. As for Groups 3 and 5, they basically comprise medium indebted countries, belonging to either the second or the third quartile of the distribution, while in Group 4 we find countries with high or medium-high debt levels.

Therefore, since neither real *per capita* GDP nor the degree of public indebtedness alone are sufficient to explain membership, in the next Section we will analyse whether other variables might have a significant influence on the heterogeneous relationship between public debt and economic growth.

As a further test to ensure the reliability of the empirical results, we have estimated the model using naïve country-group classifications based on income levels and on the level of indebtedness[24]. Table 7 reveals that grouping countries exogenously into three groups based on income levels (using the IMF classification) or based on levels of indebtedness (based on the debt to GDP levels), render higher negative estimated coefficients than those obtained using the GFE-2SLS estimator that endogenously classify the countries into five groups. Therefore, the GFE-2SLS estimator, controlling for unobserved heterogeneity is able to disclose a much more realistic differentiated impact of public debt on economic growth that is not captured by the *ad hoc* country classifications considered.

[Insert Table 7 here]

Finally, we have also explored the consequences of analysing a longer dataset with the potential driver variables[25]. To that end, we build an alternative balanced panel of annual data for 100 countries covering the period 1985-2020[26] combining dispersed databases based on different

[24] We are grateful to an anonymous referee for suggesting this exploratory analysis.

[25] We thank an anonymous referee for suggesting this additional robustness analysis.

[26] The following countries leaving the sample: Belarus, Latvia, Lithuania (which became independent in 1990), Croatia, Estonia, Kazakhstan, the Kyrgyz Republic, Slovenia, Ukraine (which became independent in 1991), the Czech and Slovak Republics (which became independent states in 1993 when Czechoslovakia was dissolved) and Bahrain, Bulgaria, Ghana and Rwanda (with numerous missing data).

methodologies and approaches (Carmen M. Reinhart's time series and Penn World Table among others) and with extensive use of procedures to fill missing data. The results of this additional robustness exercise (not presented here to save space, but available upon request from the authors) suggest that although the GFE estimator identifies five new groups of countries, the parameters estimated in our estimated model with 115 countries covering the 1995-2016 period are within the confidence intervals of the estimates obtained with the extended sample for 100 countries, giving further support and credibility to results reported in Tables 6 and 7 despite the disagreement in the classification of countries[27].

6.2. Group membership drivers

In this section we assess the role of five types of variables as underlying drivers of the heterogeneous impact of public debt-to-GDP ratio on economic growth: (1) the quality of institutions (*GQI*), (2) the composition of public expenditure that is funded with debt (distinguishing between productive government spending -*PROEXP* - and unproductive expenditure -*UNPROEXP*) , (3) the relative ratio of private debt indebtedness (*DQPRD*), (4) the relative ratio of public debt indebtedness (*DQPD*), and (5) debt maturity (*STD*).

To assess the effects of the different factors, in Table 8 we report the results of multinomial logit regressions of the five groups identified by the GFE estimator, using several specifications to sequentially include the drivers under study (see Pindyck and Rubinfeld, 1998). The base category is the group with the estimated lowest impact of public debt on growth (Group 5).

[Insert Table 8 here]

The estimated coefficients indicate that the quality of the institutions (*GQI*) positively affects the probability of belonging to Groups 1, 2, 3 and 4 relative to Group 5. The magnitude of the coefficient is inversely related to the identified order of relative impact of public debt on growth, except for Group 4. This finding can be taken as evidence that, in general, the sounder the

[27] Recall that, as explained in Section 4, data for the relevant variable (*d*, the debt-to-GDP ratio) are only available from a homogeneous source starting in 1995. So, the use of a combination of dispersed databases to extend the sample could have introduced an additional source of heterogeneity in the data under study, in contrast to the original dataset that was built from a homogeneous data source.

institutions, the less negative the effect of an increase in public debt on economic growth. This result agrees 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 public debt and economic growth.

Regarding the composition of public expenditure, the estimated results clearly indicate that the higher the ratio of unproductive expenditure to GDP (*UNPROEXP*) and the lower the ratio of productive expenditure to GDP (*PROEXP*), the higher the negative impact of the public debt-to-GDP ratio on the economic growth, correctly classifying most of the countries in the identified group. Thus, our results reinforce the idea that the impact of an increase in public debt 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)].

Turning to the relative level of indebtedness, the results suggest that the magnitude of the public and private debt ratios (*DQPD* and *DQPRD*) explains most of the differences between low and high-impact countries. These results suggest that the debt level beyond which an increase in public debt harms economic growth differs across countries. Specifically, in countries in Groups 1 and 2, the room for manoeuvre for increasing public debt is more limited (even when their level of public indebtedness is already low as is the case of countries in Group 2) rather than in countries in Groups 4 and 5 (where the estimated effect of a debt increase on growth is much lower, although their level of public indebtedness is considerably high –Group 4).

As for the relative level of private indebtedness (*DQPRD*) it turns out to have a significant negative impact on the debt-growth relationship in most of the groups (Group 3 is the exception) 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. Finally, concerning the maturity of debt (*STD*), we find that has a positive effect on the likelihood of a given country being correctly classified in the group identified by

the GFE estimator. Consequently, the higher the proportion of short-term debt, the more negative the impact of an increase in debt on economic growth. This result is consistent with the argument that short-term liabilities rend an economy particularly vulnerable as the shorter and more concentrated the debt maturity the more likely debt crises are to occur (see, e. g. Chang and Velasco, 2000). In addition, as pointed out by Barro (1979), short-term debt may increase a country's exposure to sharp increases in interest rates, which may have additional negative consequences, as governments may need to increase taxes to service the debt.

As a further test to evaluate how well our estimated models accounts for the observations, we use the five multinomial logistic regression models reported in Table 8 to predict the probabilities of the different possible outcomes given the corresponding set of independent variables and evaluate their data classification success. Recall that the multinomial logit regressions are a classification method, therefore, we have used this feature to sequentially assess if our explanatory variables render a classification of countries similar to the grouping the GFE method have endogenously identified. Table 9 displays the distribution of the classifications generated by the alternative specifications. A look at Table 9 reveals that, except for the indicator of the quality of institutions, the estimated models achieve a high classification success, and can render predicted probabilities that are close to the actual percentage frequency observed in the data. Therefore, these results offer additional evidence that the analysed explanatory variables contain useful information that allows accurate replication of the country classification generated by the GFE estimation procedure.

[Insert Table 9 here]

7. Concluding remarks

In this paper, we have re-examined the heterogeneous link between public debt and economic growth. The main contribution to the existing empirical literature is twofold. First, using a global sample that comprises 115 advanced, emerging and developing economies over the period 1995-2016, we applied the GFE method to examine the extent to which the relationship between the public debt-to-GDP ratio and economic growth differs across groups of countries. The main novelty with respect to previous literature is that this method allows us to investigate the heterogeneity of the relationship across 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 also estimate the differentiated impact of public debt for the identified groups, offering further support to the hypothesis of the existence of a heterogeneous relationship between public debt and economic growth. Secondly, this paper also contributes to the literature by analysing the drivers of the heterogeneous impact of the public debt-to-GDP ratio on economic growth. To that end, we explore the determinants of group membership, making use of a multinomial logit regression model to assess the role of 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. Therefore, our paper shifts the focus of research on the long-run effects of "high levels" of public debt towards its interplay with the deep determinants of growth –institutions and public policies– as the new growth theories have recently proposed (Capolupo, 2009).

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 time-period 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 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 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 recent health and economic crisis might have in the different countries' rate of growth.

A natural extension of the analysis presented in this paper would be to explore the potential nonlinearity within and across countries in the public debt–economic growth relationship. This is an item in our future research agenda.

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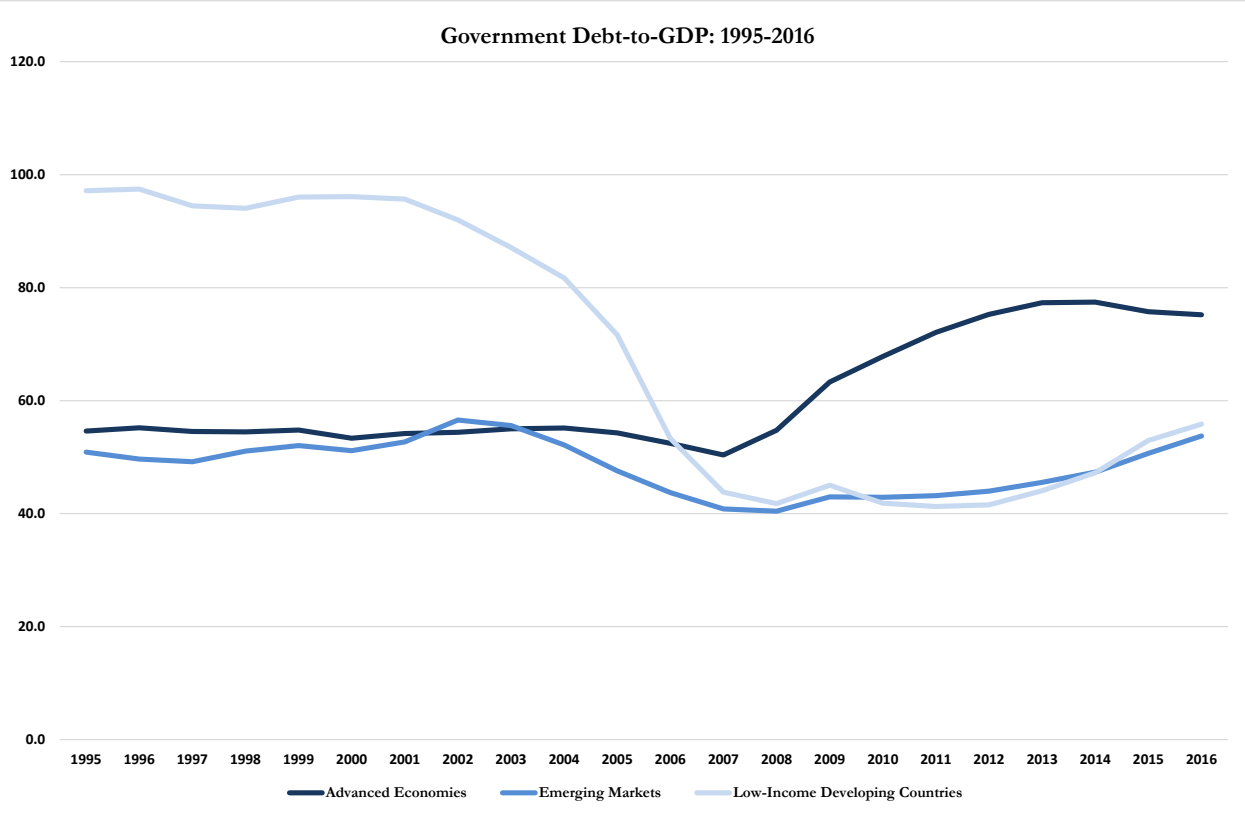
Figure 1: Government debt-to-GDP



Note:
The sample includes 115 countries divided by the International Monetary Fund into advanced, emerging market and low-income developing economies according to: (1) per capita income level, (2) export diversification, and (3) degree of integration into the global financial system.

Figure 2: Impact of public debt on economic growth by groups of countries

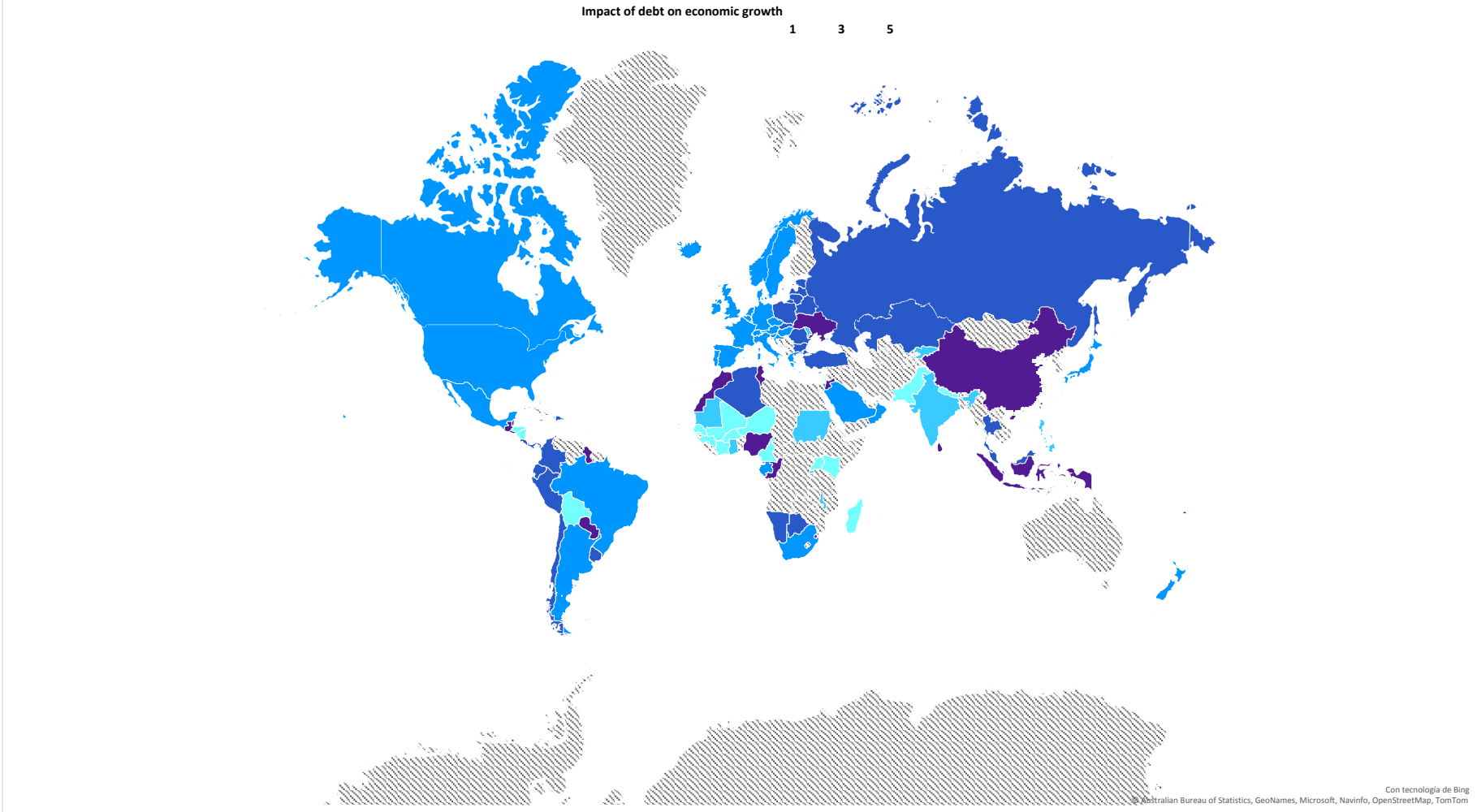


Table 1: List of 115 countries included in the sample by income group

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.

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 Development Indicators (World Bank)
Population growth (*POPGR*)	Population growth (annual %)	World Development Indicators (World Bank)
GCF-to-GDP ratio (*GCF*)	Ratio of gross capital formation to GDP (%)	World Developmentº 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)
Interest rate (*INT*)	Long-term interest rate	Penn World Table, version 10.0
Unemployment rate (*UNEM*)	Unemployed people as a percentage of the labour force (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 multinomial logit model

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. Data are in percentage of GDP.	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 (*PROEXP*)	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 (*UNPROEXP*)	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)

Table 4: Parameter estimates for the benchmark model

	OLS	FE-2SLS	GFE	GFE-2SLS
lagged y	-0.00004***	-0.00003***	-0.00001***	-0.00002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
D	-0.0166***	-0.0155***	-0.0135***	-0.0140**
	(0.0033)	(0.0031)	(0.0030)	(0.0035)
OPEN	0.0057**	0.0227***	0.00420*	0.0224***
	(0.0025)	(0.0042)	(0.0022)	(0.0041)
INF	-0.0099**	-0.0126***	-0.0100**	-0.0131***
	(0.0050)	(0.0022)	(0.0048)	(0.0025)
POPGR	-0.6962***	-0.7204***	-0.6160***	-0.7390***
	(0.0799)	(0.1209)	(0.0958)	(0.1209)
GCF	0.0750***	0.1394***	0.07520***	0.0902***
	(0.0100)	(0.0139)	(0.0218)	(0.0232)
Country FE	No	Yes	No	No
Year FE	No	Yes	Yes	Yes
Group FE	No	No	Yes	Yes
Group-year FE	No	No	Yes	Yes
Time trend	Yes	No	No	No
N	2435	2435	2435	2435
Adjusted R^2	0.3276	0.3654	0.3414	0.4134
BIC	12769.38	12613.15	12525.33	12506.80
RMSE	2.9140	2.8750	2.8020	2.7831

Notes:
The table reports estimated coefficients from the basic empirical model and its extension to exploring the possibility of heterogeneous effects, given by equations (1) and (6) respectively.
OLS, FE-2SLS, GFE and GFE-2SLS denote, respectively, results from pooled-OLS, fixed-effects two-stage least squares, grouped fixed effects, and grouped fixed effects two-stage least squares estimation methods.
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.
Robust standard errors in brackets. GFE results obtained with algorithm 1.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: 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

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 5 (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

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

Table 5 (continued)

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 6: 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*** (0.0020)
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 5 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

Table 7: Heterogeneous effects by group using naïve country-group classifications

	FE-2SLS Income Groups	FE-2SLS Indebtedness Groups
lagged y	-0.0003*** (0.0000)	-0.0002*** (0.0000)
DPDQ1* ***d***	-0.0172*** (0.0041)	
DPDD2* ***d***	-0.0180*** (0.0053)	
DPDQ3* ***d***	-0.0367** (0.0161)	
DPDQ4* ***d***	-0.0341*** (0.0101)	
DAE* ***d***		-0.0146** (0.0071)
DEM* ***d***		-0.0323*** (0.0053)
DLIDC* ***d***		-0.0162*** (0.0040)
OPEN	0.0218*** (0.0061)	0.0219*** (0.0037)
INF	-0.0126*** (0.0037)	-0.0118*** (0.0021)
POPGR	-0.7547*** (0.2421)	-0.7423*** (0.1141)
GCF	0.1127*** (0.0275)	0.0934*** (0.0129)
Country FE	Yes	Yes
Year FE	Yes	Yes
Group FE	No	No
Group-year FE	No	No
N	2435	2435
Adjusted R^2	0.3849	0.3593
BIC	12653.40	13016.54
RMSE	2.8588	2.8617

Notes:
The table reports estimated coefficients from the extended model to explore the possibility of heterogeneous effects, given by equation (1), 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 5 for the list of countries belonging to each group. DPDQ1, DPDQ2, DPDQ3 and DPQ4 are dummy variables that take the value 1 if the country belongs, respectively, to the low indebted, lower-middle indebted, upper-middle indebted, and high indebted categories using public debt-to-GDP ratios or zero otherwise. DAE, DEM and DLIDC are dummy variables that take the value 1 if the country belongs, respectively, to advanced economies (AE), emerging market economies (EM), and low-income developing countries (LIDC) or zero otherwise. The classification of countries follows the one used in the IMF's *World Economic Outlook*. Robust standard errors in round brackets. *** p<0.01, ** p<0.05, * p<0.

Table 8: Explaining group membership

	Alternative specifications				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Group 1: highest impact (*vs.* Group 5: lowest impact)				
GQI	15.03*** (1.83)				14.95*** (4.03)
PROEXP		-0.55*** (0.09)			-0.50*** (0.13)
UNPROEXP		0.33*** (0.06)			0.36*** (0.09)
DQPD			0.62*** (0.20)		0.59*** (0.16)
DQPRD			1.35** (0.56)		1.61** (0.53)
STD				0.15*** (0.03)	0.19*** (0.05)
	Group 2: upper-middle impact (*vs.* Group 5: lowest impact)				
GQI	32.89*** (1.94)				33.74*** (9.19)
PROEXP		-0.24*** (0.09)			-0.22*** (0.07)
UNPROEXP		0.28*** (0.08)			0.24*** (0.06)
DQPD			0.54*** (0.11)		0.56*** (0.15)
DQPRD			1.08*** (0.31)		1.42*** (0.38)
STD				0.12*** (0.02)	0.14*** (0.04)
	Group 3: middle impact (*vs.* Group 5: lowest impact)				
GQI	45.81*** (2.07)				45.78*** (12.77)
PROEXP		-0.19*** (0.09)			-0.20*** (0.06)
UNPROEXP		0.22*** (0.05)			0.23*** (0.06)
DQPD			0.46** (0.18)		0.43** (0.11)
DQPRD			0.85** (0.31)		0.85*** (0.16)
STD				0.10*** (0.02)	0.12*** (0.03)
	Group 4: lower-middle impact (*vs.* Group 5: lowest impact)				
GQI	4.99** (2.10)				4.93** (1.33)
PROEXP		-0.05** (0.02)			-0.04** (0.01)
UNPROEXP		0.18*** (0.04)			0.15*** (0.04)
DQPD			0.40*** (0.09)		0.33*** (0.07)
DQPRD			0.35*** (0.10)		0.41*** (0.11)
STD				0.08*** (0.02)	0.09*** (0.03)

Note:
The omitted category is Group 5. The table reports the results of a set of multinomial logit regressions of the five estimated groups, using several specifications. Robust standard errors clustered at the country level in parentheses. *** p<0.01, ** p<0.05, * p<0.1. *GQI* is a government quality indicator; *PROEXP* and *UNPROEXP* denote productive and non-productive expenditures, respectively; *DQPD* and *DQPRD* are dummies capturing relative public and private indebtedness, respectively; and *STD* is a proxy of the debt maturity. See Table 5 for the list of countries belonging to each group.

Table 9: Logit classifications.

	Observed Frequency	Predicted frequencies				
		Model 1 (Quality of institutions)	**Model 2 (Composition of public expenditure)**	**Model 3 (Relative public and private indebtedness)**	**Model 4 (Debt Maturity)**	**Model 5 (All variables)**
Group 1	15.65	19.22	15.43	15.62	15.50	15.63
Group 2	24.35	21.81	24.41	24.30	24.36	24.28
Group 3	34.78	26.66	35.01	34.82	34.85	34.75
Group 4	8.70	13.10	8.61	8.80	8.67	8.82
Group 5	16.52	19.22	15.43	15.62	16.62	16.53

Note:
The observed frequency (column 2) and the predicted frequencies (columns 3 to 7) have been generated by multinomial logit regression using different sets of independent variables: A government quality indicator (*GQI)*; productive and non-productive expenditures (*PROEXP* and *UNPROEXP*); relative public and private indebtedness (*DQPD* and *DQPRD*); and a proxy of the debt maturity (*STD*), respectively. See Table 5 for the list of countries belonging to each group.