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On the heterogeneous link between public debt and economic growth

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ABSTRACT

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

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. 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. Public debt accounted for almost 40 percent of total global debt in 2020, the highest percentage since the mid-1960s, while private debt from non-financial corporations and households also reached new highs. This was therefore a broad-based phenomenon, with government, private, domestic, and external debt all at multi-decade highs in advanced countries, and emerging market and developing economies alike. While in advanced economies, the total debt reached 300 percent of GDP in 2020 in emerging market and developing economies, the total debt reached 206 of GDP. Moreover, government debt reached more than 120 percent of GDP in advanced economies, and 60 percent of GDP in emerging market and developing countries (see Kose et al., 2021).

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[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/.

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In this scenario, the empirical study of the nexus between public debt and economic growth, a traditional research focus for economists, has become an issue of paramount importance. Therefore, this paper aims to contribute to the existing empirical literature in two respects. First, using a panel data for 115 countries over the period 1995–2016, we apply 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 estimator 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 second contribution is the analysis of the drivers of the detected heterogeneous impact of debt on economic growth. For this, we use 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.

The existing literature on the growth-debt nexus 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 has mainly focused on the nonlinear effects in the debt-growth relationship and predicts 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, which is around 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 time periods), most of the studies in this strand conclude that public debt hinders economic growth, indicating that countries are mainly in the downward-sloping part of the inverted U. The magnitude of the effect is similar among the studies, in the range 0.01–0.02 percentage points less growth linked to one percentage point increase in the debt-to-GDP ratio, as highlighted by Woo and Kumar (2015).

The "second generation" strand of studies 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), Eberhardt and Presbitero (2015), Markus and Rainer (2016), Chudik et al. (2017), Chiu and Lee (2017) and Gómez-Puig and Sosvilla-Rivero (2017 and 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. However, and possibly due to its complexity, few papers have simultaneously analysed 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 estimating 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 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, and conclude 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. Similarly, Eberhardt and Presbitero (2015) introduce non-linearities at the country level in the debt-growth nexus by using exogenously selected thresholds (they focus on 60%, the sample mean, and the popular 90% debt-to-GDP ratio), which allows them to research heterogeneous growth regimes (below and above the threshold) while accounting for cross-sectional dependence.

In this paper, we focus on the "heterogeneity" issue, since despite being very relevant, it has not yet received enough attention in the literature. Hence, our paper belongs to the above-mentioned "second generation" of studies and, without disregarding the potential existence of nonlinearity in the debt-growth relationship[5], our goal is to identify and quantify the heterogeneity of the debt-growth nexus along with the underlying factors that might explain it globally.

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 of countries into five groups that have dissimilar time patterns and a different estimated impact of public debt on economic growth (ranging between −0.027 and −0.006). When the variables driving the different impacts are analysed, 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; however, it is 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

[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.

[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)'s 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 for 1978–2008].

[4] Again, the empirical literature examines different samples of countries and periods: Ghosh 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.

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

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. The 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. Fig. 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).

We can observe that, from the onset of the global financial crisis (2008–09) until the end of the sample period in 2016, on average, government debt rose 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)]. 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 increase until 2012 (on average, 14% of GDP), which coincided 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, public debt increases are far from being homogeneous within the three groups of countries, being the debt-to-GDP ratios highly dispersed in the different groups over the sample period. More specifically, despite their relatively moderate average values in 2016, debt-to-GDP ratios registered values above 100% in eight advanced economies and above 90% in three advanced economies. 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 stands out that the United States and five euro-area countries (Italy, Portugal, Belgium, Spain, and France) also registered ratios above or close to 100% in 2016. Moreover, two emerging market and four low-income developing countries were also showing rates above 100% and 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 world's largest population, had a public debt ratio of just 44% of its GDP in 2016; however, since the onset of the Global Financial Crisis, this 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%. 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 shows 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 estimator, which leaves group membership unrestricted rather than imposing it *ex-ante*, is a more useful tool for capturing these 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 other 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 used an empirical growth model derived from the neoclassical growth 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:

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

[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.

[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.

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 their exports are oil; and (3) degree of integration in the global financial system.

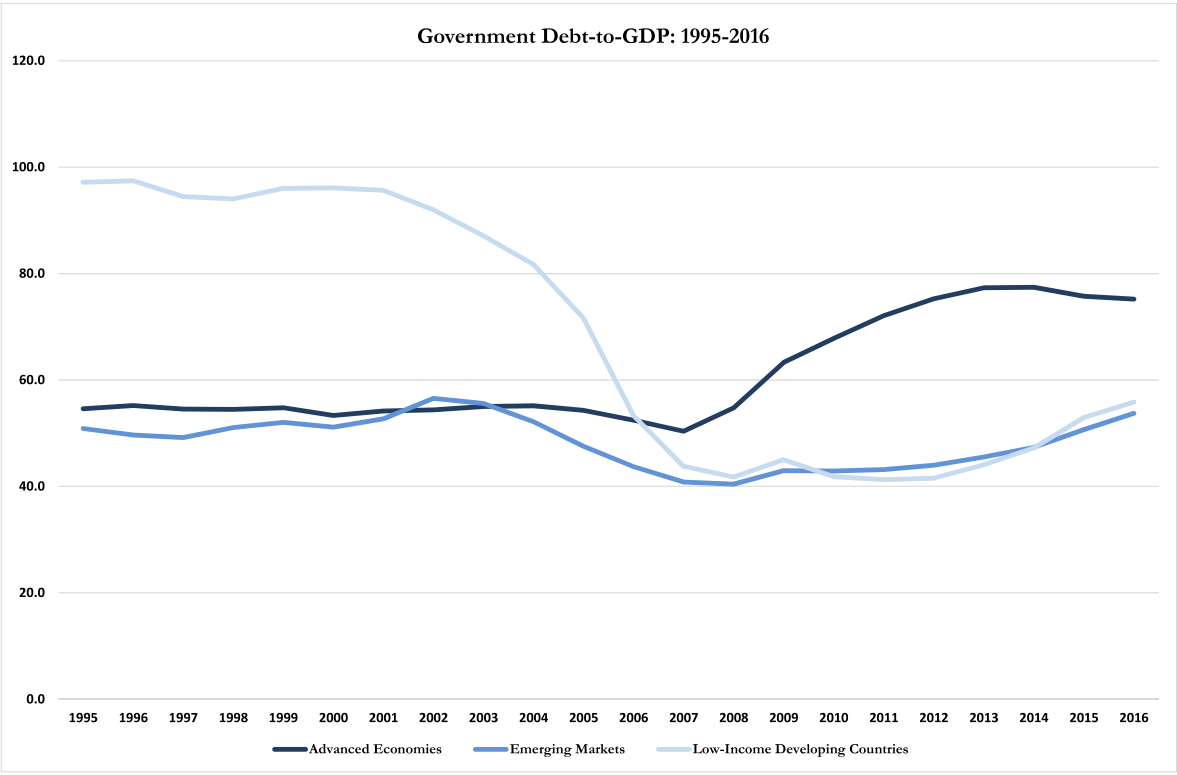

Fig. 1. Government debt-to-GDP. Note: The sample includes 115 countries divided by the International Monetary Fund into advanced, emerging market and low-income developing economies according to: (1) per capita income level, (2) export diversification, and (3) degree of integration into the global financial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

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} ($j = 1, \ldots, n$) 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 growth rate 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 growth of labour 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 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). In terms of the long-term interest rate (*INT*), most papers analysing the investment channel show that there is a negative relationship between interest rates and output [see, e.g., Haavelmo (1960), Tobin (1965) or Kydland and Prescott (1982) among others]. Recent contributions from Brunnermeier et al. (2020) and Blanchard (2019) suggest that its trajectory has 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 macroeconomic theory (Blinder, 1997) and has been found to hold for several countries and regions, mainly in developed countries [see, e. g., Tatom (1978), 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).

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

Once a heterogeneous debt-growth relationship has been found using equation (1), we explored the potential drivers of the detected heterogeneity. To this end, based on a selective review of the empirical and theoretical literature, we applied an eclectic approach and considered 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 characterization of the identified groups of countries.

In relation to 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 overlooked. To the best of our knowledge, a few exceptions are Jalles (2011), Kourtellos et al. (2013), and Kim et al. (2017), who find empirical evidence that suggests that the quality of governance, the control of corruption and the level of democracy are relevant for economic growth. We rely on the definition of economic institutions proposed by Acemoglu et al. (2005a), in which good economic institutions are the ones that provide security of property rights and relatively equal access to economic resources to a broad cross-section of society. Nevertheless, 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 a good coverage in terms of countries and periods.

Turning to the case of 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). Surprisingly, while the unprecedented increase in public debt and its scale have raised serious concerns among economists, a more nuanced position has been taken on the risks of accumulating private debt [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, including private 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. In particular, factors such as debt maturity are key elements that can affect fiscal vulnerabilities and the governments' responses to changes in debt. Therefore, as a proxy of debt

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

[9] Note also that Canzoneri et al. (2002) and Laubach (2009), among others, present evidence on the effects of interest rates on expected deficits and 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 on the debt-growth nexus, despite its relevance and the fact that several authors have 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 public expenditure funded by government debt is productive or unproductive. While the former, which includes physical infrastructures (roads and railways), communication and information systems (phone, internet), education or health facilities, 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 used 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 for some relevant variables. 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]. Concerning the model specification and the selection of explanatory variables, 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 the congruence of the final 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 used the World Bank's World Development Indicators as our main source. We then complemented our data with supplementary information from the International Monetary Fund (International Financial Statistics and World Economic Outlook, October 2018). As mentioned above, for the first empirical model we used real *per capita* GDP at 2010 market prices, the 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 used to examine the debt-growth nexus are presented in Table 2.

Turning to the variables used in our second empirical model as potential drivers of the heterogeneous debt-growth relationship, we used the WGI index as our proxy of the quality of institutions (*GQI*). 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 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 took the simple average of these four components for each country and year. We then rescaled 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 called "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 selected the variable total private debt as a percentage of GDP[12]. Then, just as the World Bank classifies countries by income (see Fantom and Serajuddin, 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 used 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

[10] Even removing the *FIN* variable from the model, the longest we could have extended 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). Therefore, we opted to keep the *FIN* variable in the model and therefore estimate it for the period 1995–2016.

[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.

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 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)
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)

Bank's World Development Indicators and from the Coordinated Portfolio Investment Survey (CPIS) database provided by the IMF.

Finally, the source for constructing the government expenditure composition variable was the International Monetary Fund Government Financial Statistics. This dataset, usually known as the classification of the functions of government (COFOG), divides government expenditure into ten categories. Following common practice in the literature [see, e. g., Kneller et al. (1999), Adam and Bevan (2005), Christie (2012) or Chu et al. (2020)], we differentiated between productive expenditures ($PROEXP_t$), including general public services *(GF01)*, defence *(GF02)*, economic affairs *(GF04)* (this 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].

The definitions and sources of the variables used to examine the potential drivers of the heterogeneous debt-growth relationship are presented in Table 3.

To produce a data matrix without missing values, we applied two complementary procedures. The first one is the technique of multiple imputation developed by King et al. (2001), which permits missing data to be approximated and therefore obtain better estimates. The second procedure is the simultaneous nearest-neighbour predictors proposed by Fernández-Rodríguez et al. (1999), which infers omitted values from patterns detected in other simultaneous time series.

5. Econometric methodology

5.1. Exploring heterogeneous effects

Given the relatively small sample available, we used panel data econometrics to combine the power of cross-section averaging with all the subtleties of temporal dependence (see Baltagi, 2008). As mentioned before, our main contribution is to provide new insights concerning the heterogeneous impact of government indebtedness on economic growth by the GFE estimator, allowing us to endogenously generate country groups according to the heterogeneity of the growth-debt relationship[14]. However, for comparative purposes we also apply standard panel data techniques.

Thus, 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 $s = 1, \ldots, T$ (strict exogeneity) and $E(d_{it}\varepsilon_{is}) \neq\neq 0$

[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.

[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.

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)

	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 elsewhere 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)
		Waste management; water waste management; pollution abatement; protection of biodiversity and landscape; R&D related to environmental protection.	Government Financial Statistics

(*continued on next page*)

Table 3 (*continued*)

Variable	Description	Source
Environment protection (*GF05*)		(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)

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 exogenous variables and the lagged values of the endogenous as instruments. Semykina and Wooldridge (2010) suggest using 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 about error distributions.

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 GFE approach proposed by Bonhomme and Manresa (2015). 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 for establishing 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 mentioned above, the most appealing feature of this approach is that group membership is left unrestricted. The estimator is suitable for large N and medium T and it is consistent when both dimensions of the panel tend to infinity.

In contrast to the two-way fixed-effects estimator, the most common approach for modelling time-invariant unobserved heterogeneity in panel data, which 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, and thus overcomes the above mentioned problems. Both the group-specific time patterns and group membership are estimated from the data. The relationship between the observed variables and the unobserved group heterogeneity is unrestricted, which allows 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:

$$g_{r_j} = z_{it}^{'}\theta + \alpha_{g_{r_j}t} + \vartheta_{it}, i = 1, ..., N,\ \ t = 1, ..., T \tag{2}$$

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 can be arbitrarily correlated with group-specific unobserved heterogeneity $\alpha_{g_{r_i}t}$. The countries in the same group share the same time profile and the number of groups is decided or estimated by the researcher.

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 $\ddot{g}_{it} = g_{it} - \overline{g}_t, \ddot{z}_{it} = z_{it} - \overline{z}_t$, etc. The GFE in equation (2) with the transformed variables assuming that θ is common for all groups is the outcome of the minimization of the following expression:

$$(\widehat{\theta}, \widehat{\alpha}, \widehat{\gamma}) = \underset{(\beta,\alpha,\gamma)\in\Theta^G x A^{TG} x \Gamma_G}{argmin} \sum_{i=1}^{N}\sum_{t=1}^{T}\left(\ddot{g}_{it} - \ddot{z}_{it}^{'}\theta_{g_{r_j}} - \ddot{\alpha}_{g_{r_{ij}}t}\right)^2, \tag{3}$$

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. T is the number of periods. The parameter spaces Θ and A are subsets of R^K and R, respectively. We denote as γ the set of all $\ddot{\alpha}_{g_{r_{ij}}t}$'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

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

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:

$$\widehat{g}_{r_j}(\widehat{\theta},\widehat{\alpha}) = \underset{g_r\in[1,\ldots,G]}{argmin}\sum_{t=1}^{T}\left(\ddot{g}_{it} - \dot{z}_{it}^{'}\theta - \ddot{\alpha}_{g_{rij}t}\right)^2, \tag{4}$$

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

$$(\widehat{\theta},\widehat{\alpha}) = \underset{(\beta,\alpha)\in\Theta x A^{TG}}{argmin}\sum_{i=1}^{N}\sum_{t=1}^{T}\left(\ddot{g}_{it} - \dot{z}_{it}^{'}\theta - \ddot{\alpha}_{\widehat{g}_{r_j}(\beta,\alpha)t}\right)^2, \tag{5}$$

where $\widehat{g}_{r_i}(\widehat{\theta},\widehat{\alpha})$ is given by (4) 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 ran GFE estimations with a number of groups G varying between 1 and 6 and calculated 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 for modelling 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.

As explained, an important feature of the GFE estimator is that group membership of the countries in our sample is not predetermined but is estimated according to a least-squares criterion. Countries with the most similar time profiles of the outcome variable (growth rate of real *per capita* GDP) – net of the effect of covariates – are grouped together. Assume that the countries in our sample are categorized into 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:

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

where $\alpha_{j_i t}$ denotes the group-specific time fixed effects. In our empirical application the coefficient of d_{it} is allowed to vary between groups once group membership has been determined.

Moreover, 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 standard errors clustered by countries, using the exogenous variables and the lags of the endogenous variable (debt-to-GDP ratio) 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 being allocated 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:

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

where $j = 1, 2, 3, \ldots, J$ corresponds to identified groups ordered by their 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 connected (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.

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

6. Empirical results

6.1. Heterogeneous debt-growth relationship

Table 4 shows the results obtained by estimating the growth model by OLS, FE-2SLS, GFE and GFE-2SLS in columns (1) to (4), respectively[17]. Recall that unlike OLS, the FE-2SLS estimation method accounts for country heterogeneity and endogeneity of the target variable, the GFE estimator controls in addition correlated unobserved heterogeneity, and the GFE-2SLS method also considers the endogeneity of the debt variable. It should be noted that the variables *HK*, *INT*, *UNEM* and *FIN* were non-significant, so following the general principle of parsimonious data modelling (see, e. g., Haavelmo, 1944, 74-75), they were excluded from the final estimations[18].

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[19]. Compared to the results in the OLS specification, the coefficient of the public debt-to-GDP ratio is slightly lower in magnitude in all the other estimations, as shown in columns (2) to (4) in Table 4 but remains statistically significant. According to the GFE-2SLS results, an additional point on the public debt-to-GDP ratio is associated with a reduction in the growth rate by 0.014 in the GFE-2SLS estimation. This is our preferred estimator since it accounts for the endogeneity of the debt variable, 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, which is equivalent to a decrease of about 22%[21].

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

The GFE-2SLS model uses five groups (the number has been selected using the information on the change in the BIC). The estimated classification of the countries belonging to each group is listed in Table 5[23].

Next, to determine 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 interactions of the debt variable (d_{it}) with the group indicator variables. Table 6 presents the estimation results of the impact of the debt-to-GDP ratio on real *per capita* GDP growth for each of the five groups in the sample and a mapping of the effects is shown in Fig. 2. Note that, for expository convenience, we have ordered the groups according to their estimated impact. Group 1 has the highest estimated impact and Group 5 has 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 from −0.027 in Group 1 to −0.006 in Group 5. These results imply that 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 economies except for four that are low income developing countries (Cape Verde, Congo Republic, Nigeria, and Guyana). Group 2 encompasses 28 countries, the majority of which are emerging market 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 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 emerging market economies (Saudi Arabia, Brazil, Argentina, and South Africa, among them). Finally, two-thirds of the economies in Groups 4 and 5 (they show the lowest impact of debt on economic growth) are Sub-Saharan African low income developing countries. Group 4 is composed of 10 countries that are low income developing countries,

[17] We performed a variety of unit root tests in panel datasets to assess the time-series properties of the variables under study, and the results of the tests are available upon request from the authors. However, for both statistical (these tests have notoriously poor power and they do not handle the possible breaks and cross-sectional dependences) 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 the public debt-to-GDP ratio on growth, checking for the usual potential determinants.

[18] 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 non-statistically significant variables.

[19] In each model, we focus our comments on the public debt to study 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.

[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 tests by Sargan (1958) and Basmann (1960) 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, and 0.50 is 22% of this.

[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 by 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.

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 the 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.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

except for India and the Philippines (emerging market economies), while Group 5 includes 19 low income developing countries, except for Nepal, Pakistan and Senegal, which are also emerging market economies.

Regarding the public debt-to-GDP ratio, Group 1 contains highly indebted countries (in the highest quartile of the sample), while Group 2 is predominantly composed of low indebted countries (in the lowest quartile of the sample). Groups 3 and 5 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 analyse the extent to which other variables have an 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) leads to higher negative estimated coefficients than those obtained using the GFE-2SLS estimator, which endogenously classifies the countries into five groups. Therefore, the GFE-2SLS estimator, taking into account 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.

Finally, we have also explored the consequences of analysing a longer dataset with the available control variables[25]. To this end, we built an alternative balanced panel of annual data for 100 countries covering the period 1985–2020[26], combining several databases based on different 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[27]. The results of this additional robustness test (not presented here to save space, but

[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 a lot of missing data).
[27] Recall that, as explained in Section 4, data for the relevant variable (the debt-to-GDP ratio) are only available from a homogeneous source starting in 1995. Therefore, the use of a combination of several 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.

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
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

(*continued on next page*)

Table 5 (*continued*)

GROUP 3:	*Region*	*Income group*	*Other classifications*	*Public indebtedness*	*Private indebtedness*
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
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 into 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 their 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. We have classified the relative public and private indebtedness, based on public and private debt-to-GDP ratios, 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 quartiles.

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.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

available upon request from the authors) suggest that the GFE estimator also identifies five groups of countries, and 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. This finding provides further support to the results reported in Tables 6 and 7.

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).

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

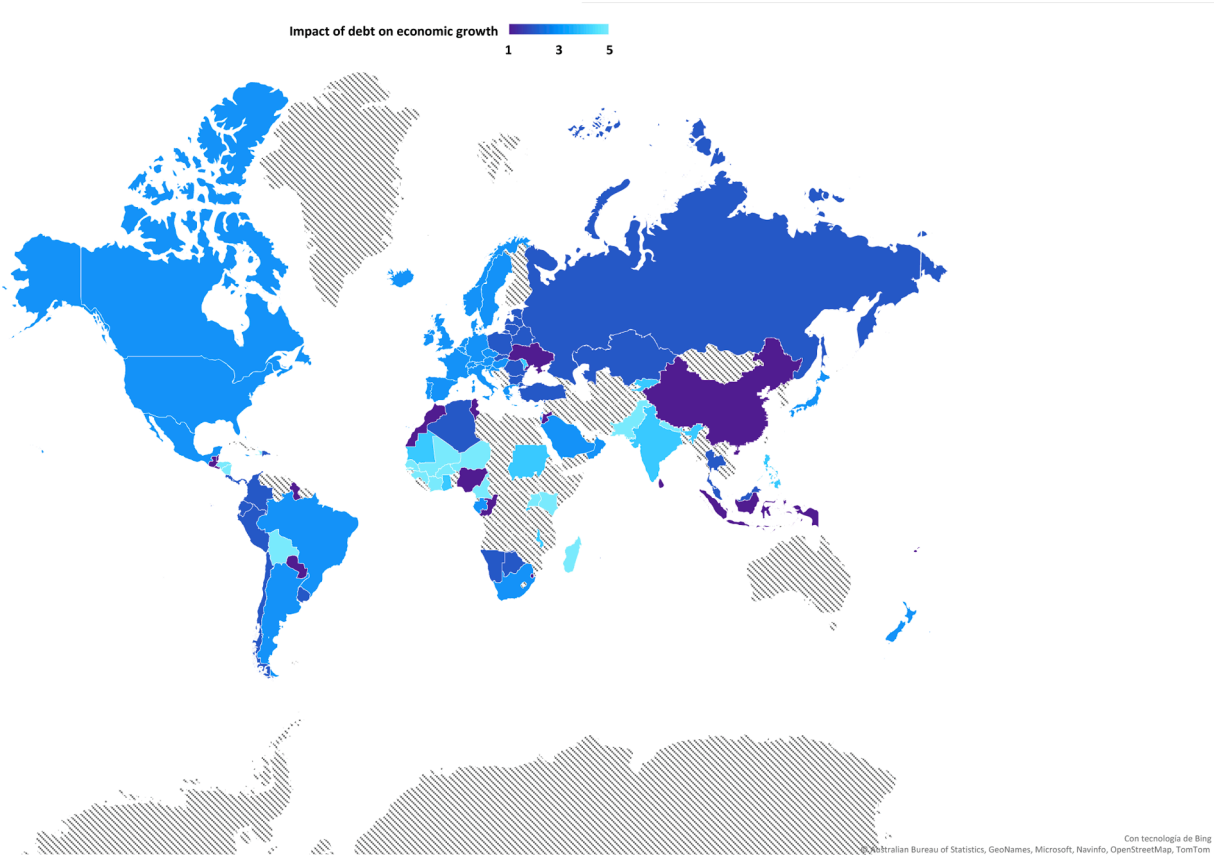

Fig. 2. Impact of public debt on economic growth by groups of countries.

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) 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 in Group 4).

The relative level of private indebtedness (*DQPRD*) has 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) and Jordà et al. (2016), among others, who highlighted the negative implications of excessive private debt for growth and financial stability. Finally, we found that the maturity of debt (*STD*) 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 render an economy particularly vulnerable because the shorter and more concentrated the debt maturity the more likely that a debt crisis will 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 account for the observations, we used 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 evaluated their data classification success. Recall that the multinomial logit regressions are a classification method; therefore, we used this feature to sequentially assess whether our explanatory variables render a classification of countries similar to the grouping that the GFE method identified endogenously. Table 9 shows 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 can be used to accurately replicate the country classification generated by the GFE estimation procedure.

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

	FE-2SLS Income Groups	FE-2SLS Indebtedness Groups
lagged y	0.0003***	−0.0002***
	(0.0000)	(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***	0.0219***
	(0.0061)	(0.0037)
INF	−0.0126***	−0.0118***
	(0.0037)	(0.0021)
POPGR	−0.7547***	−0.7423***
	(0.2421)	(0.1141)
GCF	0.1127***	0.0934***
	(0.0275)	(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. *** $p < 0.01$, ** $p < 0.05$, * $p < 0$.

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, and group membership is estimated along with the other parameters in the model by minimizing the sum of squares of residuals. A two-stage least squares method was combined with the GFE estimator to address the potential endogeneity of the public debt-to-GDP ratio. In addition, we also estimated 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 this end, we explored the determinants of group membership, using 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.

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

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 have been 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

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.

on economic growth (ranging from −0.027 in Group 1 to −0.006 in Group 5). When we analysed the underlying variables driving the classification of countries in these 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 on 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.

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.

CRediT authorship contribution statement

Marta Gómez-Puig: Conceptualization, Writing – original draft, Writing – review & editing. **Simón Sosvilla-Rivero:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Validation. **Inmaculada Martínez-Zarzoso:** Software, Formal analysis, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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