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Three Empirical Essays on Globalization and Growth

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Three Empirical Essays on Globalization and Growth

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Neuchâtel, le 24 septembre 2018

Le doyen

Mehdi Farsi

Abstract

This thesis investigates empirically three growth-related topics: the impact of foreign direct investment (FDI) on economic growth, the impact of trade with China on African economic growth and the relationship between public debt and economic growth. The results of these three studies help to better understand the economic growth process and provide some hints on how to promote and sustain it. Chapter 1 contains an analysis of causality between FDI and gross domestic product (GDP) growth and demonstrates that causality tends to be from FDI to GDP growth and positive and that host country social and economic conditions might have an impact on GDP per capita and on FDI inflows[1]. In Chapter 2, African trade with China is analyzed and the results show that it has had a positive global influence on African economic growth but only since the beginning of this century and that, during this period, trade with China has had more influence on African economic growth than trade with the EU did[2]. The study of the debt-growth relationship at the country level is presented in the last Chapter. It highlights the importance of country specificity. Indeed, the results regarding cointegration, nonlinearity, the value of the debt threshold and the impact of public debt on economic growth are different among the considered countries.

Keywords: economic growth, foreign direct investment, causality, trade, public debt, nonlinearity.

[1] Chapter 1 was published in the *International Journal of Business and Social Sciences*, August 2015, Vol.6, No.8, 15-27.
[2] Chapter 2 was published in the *African Development Review*, June 2014, Vol.26, No.2, 397-415.

Résumé

Cette thèse étudie empiriquement trois thèmes liés à la croissance : l'impact des investissements directs étrangers (IDE) sur la croissance économique, l'impact du commerce avec la Chine sur la croissance économique africaine et la relation entre la dette publique et la croissance économique. Les résultats de ces trois études aident à mieux comprendre le processus de croissance économique et fournissent des indications sur la façon de la promouvoir et de la soutenir. Le chapitre 1 comprend une étude de la causalité entre les IDE et la croissance du produit intérieur brut (PIB). Elle démontre que la causalité tend à aller des IDE vers la croissance du PIB et à être positive et que les conditions sociales et économiques du pays receveur peuvent avoir un impact sur le PIB par habitant et les flux entrants d'IDE[1]. Le Chapitre 2 analyse le commerce de pays africains avec la Chine. Les résultats montrent que ce commerce a une influence globale positive sur la croissance économique en Afrique mais seulement depuis le début de ce siècle. Ils indiquent également que durant cette période, le commerce avec la Chine a eu plus d'influence sur la croissance économique africaine que n'en a eu le commerce avec l'UE[2]. L'étude de la relation entre la dette publique et la croissance au niveau d'un pays en particulier est présentée dans le dernier chapitre. Elle met en évidence l'importance de la spécificité de chaque pays. En effet, les résultats concernant la coïntegration, la non-linéarité, la valeur du seuil de la dette et l'impact de la dette publique sur la croissance économique sont différents selon le pays considéré.

Mots-clés : croissance économique, investissements directs étrangers, causalité, commerce, dette publique, non-linéarité.

[1] Le chapitre 1 a été publié dans: the *International Journal of Business and Social Sciences*, August 2015, Vol.6, No.8, 15-27.
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To Steve

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General Introduction

1. Motivation and structure

Since centuries, growth has been at the core of economic analysis. It is difficult to find any area of economics which is not, in one way or another, related to the growth issue. At the same time, in spite of its prevalence and the huge literature on the subject, it is fair to say that our understanding of economic growth ought to be improved, and many countries still struggle with poor growth performance. Why do some countries manage to improve their growth performance while others cannot? Most economists will agree that growth is a multifactor phenomenon, involving complex interactions between core variables, such as goods and services, ideas, policies and institutions, which are not evident to articulate theoretically nor to disentangle empirically. Moreover, the recent literature has also emphasized that the growth path is not unique, and depends on country-specific conditions (e.g. Rodrik (2007), Acemoglu and Robinson (2012) or Sala-i-Martin et al. (2013)).

Building upon recent empirical methodologies and data, the three chapters of this PhD thesis constitute an up-to-date illustration of the empirical challenges involved in growth analysis, with a particular focus on country-specific factors. The choice of topics and methodologies was governed by two preoccupations. On the one hand, the selected issues should relate to present day relevant economic policy debates. On the other hand, the empirical framework should address endogeneity and causalities issues, control for non-linearities and include country-specific socio-economic indicators. Overall, the general lesson is one of humility and caution. Whether in terms of significance, magnitude or sign of the corresponding coefficients, the impact of growth determinants turns out to be highly country-specific. Thus, before applying general recommendations provided by empirical studies and/or international institutions, governments should adjust them according to their own socio-economic conditions and mechanisms.

The first chapter investigates the causal link between FDI and economic growth for various developed and developing countries and highlights the importance of local characteristics in shaping the relationship between these two variables. Chapter 2 consists in an analysis of the global impact of trade with China on African countries' economic growth. It points out that the impact of openness to trade on economic growth may vary among the kind of commodities which are traded, trading partners and the period of time which is considered. In the last chapter, a specific econometric methodology is used in order to detect a possible nonlinearity in the relationship between public debt and growth in several Organisation for Economic Co-operation and Development (OECD) countries.

This analysis is performed for each country separately and confirms that considering one country's own characteristics is essential in order to outline appropriate policies.

2. Overview

Since the late 1980s, FDI inflows into developing countries have increased rapidly in almost every region of the world. This has nurtured a large empirical literature on the benefits of FDI on growth, although the precise relationship between FDI and economic growth is still a matter of debate. The first chapter of this thesis tries to improve the analysis of the causal link between FDI and economic growth in several dimensions. First, rather than using a limited number of countries, it relies on a larger data set of 54 developed and developing economies. Second, it covers a long and more recent time period (1980-2013), which coincides with the moment of the upsurge of world FDI flows. Third, it considers systematically two-way Granger-causality tests and a variety of host country indicators (inflation, openness to trade, gross fixed capital formation, domestic credit provided by the banking sector, infant mortality rate and primary completion rate), which are introduced directly into the econometric specification. The estimates are performed by means of a dynamic panel data model (system generalized method of moments (GMM) estimator). Fourth, as Granger-causality results are sensitive to the lag-length of the independent variables, this study follows for the first time a rigorous lag selection process based on the Bayesian information criterion. According to the results, no Granger-causality can be observed between FDI and economic growth and these two variables are influenced by host country social and economic conditions. The results also reveal that the optimal lag-length is not identical for each explanatory variables. If we correct for the cyclical disturbances contained in the series by averaging them over several years, the results are different. They reveal that FDI positively Granger-causes economic growth and that FDI is only influenced by its own past values. The specifications performed for the two subsamples of countries defined according to their income level confirm that there is a positive causal link from FDI to GDP per capita and that no reverse causality can be observed. In these additional specifications, host country local conditions, in particular domestic investment, also play a role for the two variables of interest.

Trade between China and African countries has been booming for almost 20 years. At the same time, robust economic growth has been prevalent in most African countries. Has Chinese demand played a role in the acceleration of African output growth? The rapid growth of the Chinese economy has created a strong demand for many African major export commodities, such as oil and other raw materials, while Africa has clearly benefitted from increased imports of cheap manufactured goods from China. Chapter 2 examines the impact of Chinese trade on African growth for 37 countries from 1985 to 2012 by means of panel data econometric models. This study adds to the existing literature by enriching the empirical framework in several ways. First, it considers not only Africa's trade with China and the rest of the world but also trade with Africa's other two main trading partners: the European Union (EU) and the USA. Second, we control for a number of determinants such as savings or macroeconomic stability, which have been shown to be significant contributors to growth. Third, as trade between Africa and China has been intensifying since the beginning of the current century, the same analysis is performed between two different sub-periods (before and after the year 2000). Fourth, a number of alternative specifications are estimated in order to establish the robustness of the analysis. The openness to trade variables provide interesting results. First, total openness to trade has a positive influence on African growth. Second, disaggregating across trading partners reveals that for Africa, trade with the EU as well as with the rest of the world is beneficial to the economy. Trade links with the USA appear to have a negative impact on GDP growth during the first sub-period while it has no influence on it during the last decade. Regarding openness to trade with China, it has a positive global influence on economic growth but only during the final decade of the period under consideration, a period during which the dynamics of trade between China and Africa became much stronger. Moreover, during the same period, openness to trade with China has more influence on African economic growth than does openness to trade with the EU. This suggests that a substitution has taken place between the impact of openness to trade with the EU and openness to trade with China during the final ten years of the period under consideration. Additional specifications' results indicate that petroleum, petroleum products and related materials seem to be the most important commodities in African trade relations with China. In sum, the recent surge in trade flows between Africa and China may have important long-term consequences for the African continent.

Chapter 3 investigates the possible nonlinearity in the relationship between public debt GDP ratio and economic growth. Over the past decade, and in particular in the aftermath of the economic and financial crisis that started in 2008, fiscal sustainability has deteriorated markedly in many European countries. This led to a renewed interest in the relation between public debt and economic growth among policy-makers and economists. With some exceptions, none of the recent studies examine the link between public debt and economic growth as well as a possible debt-value threshold for each country individually, which is the aim of the present study. Indeed, a good understanding of the relation between debt and growth is crucial for an adequate guidance of public policies. We consider 17 OECD countries taken separately over the 1970-2014 period. We test for a possible cointegration between the two variables of interest and the corresponding debt-value threshold is endogenously estimated following Hansen's (1996, 1999) methodology, while simultaneously controlling for additional growth determinants. Our results' main conclusion is that the relationship between economic growth and public debt ratio varies among countries and that, for most of them (13 out of 17), this link is linear. These two findings contradict most papers on the debt-growth link, which state that not only the relationship between the two variables of interest is nonlinear but also that the debt-value threshold is common to all countries. Analyzing the relationship for each country individually is revealed to be essential for governments to shape appropriate fiscal policy guidelines. As there is no universal recipe, fiscal policy measures applied by governments in order to stimulate growth or to solve public debt problems should depend on the country's own characteristics.

Chapter 1
Impact of Foreign Direct Investment on Economic Growth: Do Host Country Social and Economic Conditions Matter?

1. Introduction

Since the late 1980s, FDI inflows into developing countries have increased rapidly in almost every region of the world. After having reached a peak in 2007 with US$ 1,8 trillion, global FDI flows began to bottom out because of the worldwide financial and economic crisis. After a 16% decline in 2008, global FDI inflows fell a further 37%, while outflows fell some 43%. However, despite this worldwide decline, the share of FDI flows to developing and transition countries - compared to those to developed economies - has been steadily growing. This type of FDI has proved less volatile than the one going to industrialized countries and, in 2009, accounted for half of worldwide FDI flows. Recently, it can also be observed that one of the fastest-growing FDI segments are flows from developing countries into other developing economies (United Nations Conference on Trade and Development (UNCTAD), 2010). In 2013, according to UNCTAD (2014), global FDI clearly returned to growth. FDI flows to developed countries increased by 9 per cent to $566 billion, leaving them at 39 per cent of global flows, while those to developing economies reached a new high of $778 billion, or 54 per cent of the total. The balance of $108 billion went to transition economies. Developing and transition economies now constitute half of the top 20 ranked by FDI inflows.

FDI-friendly policies are based on the belief that FDI, apart from bringing in capital and creating jobs, has several positive effects which include productivity gains, technology transfers and the introduction of new managerial skills and know-how into the domestic market. Nevertheless, it can also happen that FDI may harm the host economy (see Herzer, Klasen and Nowak-Lehmann D., 2006), for instance when foreign investors claim scarce resources or reduce investment opportunities for local investors. There is also some concern that no positive knowledge spillovers may finally occur within developing countries, because multinationals will prove able to protect their firm-specific knowledge, or because they may buy their inputs from foreign rather than domestic suppliers.

These ambiguities have opened the scope for a large empirical literature on the benefits of FDI on growth, although it is fair to say that the evidence gathered so far remains ambiguous. While some authors found no significant relation between FDI and growth, others showed either an unconditional positive link between these two variables or a relationship that depends upon to particular characteristics of the host country, such as the level of human capital or the depth of the financial system. At least two reasons explain these mixed results. First, most of the authors analyzed the correlation between FDI and growth using a regression analysis framework that is silent on the causality between these two variables. Second, in the studies that do address the causality issue, the influence of other social and economic variables is most of the time simply ignored.

This paper is aimed at combining both approaches simultaneously. To our knowledge, there are only three studies that combine Granger-causality tests with the inclusion of control variables referring to host country characteristics in the empirical setting. The first one is Nair-Reichert and Weinhold (2000), who use a mixed fixed and random (MFR) panel data method to allow for cross country heterogeneity in the causal relationship between FDI and growth. They examine 24 developing economies from 1971 to 1995. Their results suggest that the relationship between FDI and economic growth in developing countries is highly heterogeneous and that there is some evidence that the impact of FDI on growth rate is higher in more open economies. The second paper is Omran and Bolbol (2003), who use cross-country regressions and Granger-causality to show that, in Arab countries, FDI will have a favorable effect on growth if interacted with financial variables at a given threshold level of development. The third study is Dhakal, Rahman and Upadhyaya (2007), who use regression techniques to analyze FDI-growth Granger-causality and the influence of institutional and economic factors. They consider only nine Asian countries and when they include host country variables into the specification, the sample size is very low (5 years). They conclude that FDI-to-growth as well as growth-to-FDI causality is reinforced by host countries characteristics, such as trade openness, bilateral aid or political rights. The present paper is close to the three above studies in terms of methodology, but tries to improve the analysis in several dimensions. First, rather than using a limited number of countries, it relies on a larger data set of 54 developed and developing economies, enlarging the scope to identify relevant host country characteristics. Second, it covers a long and more recent time period (1980-2013), which coincides with the moment of the upsurge of world FDI flows. Third, it considers systematically two-way Granger-causality tests (Nair-Reichert and Weinhold (2000) only consider one-way causality from FDI to growth) and a variety of host country indicators (Omran and Bolbol (2003) only examine financial indicators). The estimates are performed by means of a dynamic panel data model (system GMM estimator). Fourth, as Granger-causality results are sensitive to the lag-length of the independent variables, this study conducts for the first time a rigorous lag selection process based on the minimization of the model and moment selection Bayesian information criterion (MMSC-BIC). In the past, only a few authors (like Holtz-Eakin, Newey, and Rosen, 1988 and Choe, 2003, for example) have used a selection process but, in these cases, the lag-length has been assumed to be the same for all right-hand-side variables, which is a strong constraint. All the previous factors contribute to provide more systematic and robust evidence on the link between FDI and GDP per capita once controlling for host country characteristics.

The paper proceeds as follows. The literature survey is presented in section 2. Section 3 describes the econometric framework for testing Granger-causality within a dynamic panel data model including the control variables and the optimal lag-length selection procedure. Section 4 summarizes the empirical findings and section 5 concludes.

2. Literature Survey

Empirical studies on the relationship between FDI and GDP are diverse in terms of data coverage and empirical methodology (cross-country, panel data and time series models). They suggest that the FDI-growth relationship is not unique and that it is conditioned by a number of other factors, such as trade openness, financial depth or human capital.

2.1 Correlation studies

The first type of analyses includes correlation studies with control variables. Among them, regarding the effect of FDI on growth in developing countries, Balasubramanyam et al. (1996) find that trade openness is crucial and Borensztein et al. (1998) show that this relationship depends on the level of human capital in the host country. From his analyses, De Mello (1999) found that the relationship between FDI and economic growth tends to be weak and conditional on host country characteristics. Carkovic and Levine (2002) use the GMM dynamic panel data estimator and allow FDI to influence growth differently depending on national income, trade openness, education and domestic financial development. They find that FDI does not exert a robust and positive impact on economic growth. In their study, Alfaro et al. (2004) examine the links among FDI, financial markets and economic growth in 71 countries. Their empirical evidence suggests that FDI plays an important role in contributing to economic growth but also that the level of development of local financial markets is crucial for these positive effects to be realized. Another important study is the one of Johnson (2006), who finds that FDI inflows enhance economic growth in developing countries but not in developed ones. Khondoker (2007) uses panel data for 60 low-income and lower-middle income countries in 2003, 2004 and 2005 and cross-section estimations. The author concludes that FDI significantly affects GDP growth and, in addition, that this relation depends on host country conditions such as a business friendly context or modern communication facilities, for instance. Alguacil et al. (2011) use dynamic panel data and cross-section regressions in order to analyze the influence of local conditions on the relation between FDI and growth. They consider 26 emerging countries from Latin America and Asia over the period 1976-2005. Their study shows the importance of considering internal and external macroeconomic stability as well as the quality of institutions when evaluating the economic impact of FDI inflows. In his study, Solomon (2011) analyses how the impact of FDI on economic growth, but not the reverse, is affected by host country factors. The author applies the system GMM estimator to a panel of 111 countries from 1981 to 2005 and finds that the level of economic development, human capital and quality of the political environment all significantly affect the relationship between inward FDI and growth. In his study, Brenner (2014) uses panel GMM regressions to examine the link between FDI and economic growth in 112 countries. He divides the countries in three groups according to their development level and performs his analyses for two separated time periods (1974-1991 and 1992-2009). The results clearly differ between the less developed countries and the other country groups and between the time periods. In less developed countries, FDI has a negative effect on economic growth during the two sub-periods. For the first time period, the author finds that FDI has positive effects on economic growth in medium and more developed countries. During the second time period, the coefficient of FDI has a positive sign for more developed countries but it is not statistically significant contrary to the one for the medium developed countries, which is still positive. Gui-Diby (2014) investigates the impact of FDI on economic growth (but not the reverse) in 50 African countries during the period from 1980 to 2009. On the basis of system GMM estimations, he finds that the impact of FDI on economic growth in the African region during the period of interest is significant but that its sign is negative before 1995 and positive thereafter. The author also comes to the conclusion that the FDI's effect is influenced by local conditions, such as government consumption for example. In can be noted that most of these studies' results clearly demonstrate the importance of local conditions (see also Almfraji and Almsafir (2014)).

2.2 Causality studies without additional control variables

Regarding the different studies analyzing causality between FDI and GDP, Choe (2003) considers 80 countries over the period 1971-1995 and uses a panel vector autoregressive (VAR) model. The results show that FDI Granger-causes economic growth, and vice-versa. On the basis of Toda-Yamamoto no-causality test, Chowdhury and Mavrotas (2005) show that the causality between FDI and growth vary among countries and Frimpong and Oteng-Abayie (2006) find in the case of Ghana a causality relationship from FDI to GDP growth, but only since 1984. In his study, Al Nasser and Omar (2010) examines 14 Latin American and Asian countries from 1978 to 2003. He found that the direction of causality is from economic growth to FDI and not the reverse for Asian countries and that there is bidirectional causality for Latin American economies. In his analysis, Esso (2011) use the Pesaran et al. (2001) approach to cointegration and the procedure for non-causality test of Toda and Yamamoto to examine the relation between FDI and economic growth in some SSA countries. He finds that there is a causal link between FDI and economic growth but that it differs among the considered countries. Moudatsou (2011) analyses the causality between FDI and economic growth in the EU and in the Association of Southeast Asian Nations (ASEAN) countries over the period 1970-2003. By means of vector error correction models (ECM), he finds that GDP causes FDI in the EU. In the ASEAN countries however, the results vary among the different countries. Sandalcilar and Altiner (2012) study the causal relation between FDI inflows and GDP in the region of ten Economic Cooperation Organization (ECO) over the period 1995-2011. They perform Granger-causality test based on ECM as well as on Holtz-Eakin, Newey and Rosen (1988) panel causality test. According to the authors' results, there is two-way causality between FDI and GDP in the ECO region. Mehic et al. (2013) investigate the impact of FDI on economic growth in seven southeast European countries in the period 1998--2007. The authors take into account several local indicators and use Prais-Winsten regressions with panel-corrected standard errors. They find that there is a positive and statistically significant effect of FDI on economic growth. Furthermore, they also test whether there is Granger-causality between FDI and GDP but, this time, without including the additional host country variables. They find that FDI Granger-causes economic growth but not the reverse. The eight above studies are examples of causality analysis that do not include additional host country indicators in the econometric specification. Abbes et al. (2015) analyze causality between FDI and economic growth for 65 countries over the 1980–2010 period using co-integration and panel Granger causality tests in panel data. The results indicate a positive unidirectional causality from FDI to GDP.

Apart from these extreme cases, some papers include additional dimensions by comparing results across countries with different characteristics or by splitting the sample according to various economic criteria. However, as mentioned before, they fall short of a systematic analysis of the impact of host country characteristics as they do not explicitly include additional control variables into the empirical framework.

2.3 Causality studies which include additional dimensions

One of the earliest studies of this latest group is Zhang (2001), who examines 11 developing countries in East Asia and Latin America covering the period 1970-1995. By considering host countries specific characteristics on the basis of descriptive statistics, he finds that the role of FDI in host economies seems to be sensitive to their economic conditions, such as openness to trade, education, macroeconomic stability, etc. Basu et al. (2003) examine a panel of 23 developing countries from 1978 through 1996. By dividing the sample according the year where trade liberalization took place, the authors found that there is a long-run causality from growth to FDI in relatively closed economies and that there is bidirectional causality in both the long-run and the short-run in the relatively open countries. In their study, Hansen and Rand (2006) analyze a sample of 31 developing countries for the period

1970-2000. Their empirical evidence indicates that FDI has a lasting impact on GDP, whereas GDP has no long-run impact on FDI. Furthermore, they consider the influence of development variables but only within cross-plots. They find that the relationship between FDI and economic growth is not influenced by the level of development. Herzer et al. (2006) examine the FDI-led growth hypothesis for 28 developing countries over the period 1970-2003. They find that in the majority of countries FDI has no significant long-run impact on growth. On the basis of simple scatter plots, they also came to the conclusion that there is no clear influence of the level of per capita income, the level of education, the degree of openness and the level of financial market development.

Regarding the existing literature on this topic, it must also be mentioned that some authors incorporate (only) a third variable directly in the econometric specifications. For example, Ahmadi and Ghanbarzadeh (2011) performed Granger-causality tests for the variables FDI, economic growth and exports. They consider MENA countries over the period 1970-2008 and use panel VAR models. Their findings indicate that there are bidirectional causality relations among all three considered variables. In his paper, Tekin (2012) analyses potential Granger-causality among GDP, exports and inward FDI in Least Developed Countries over the period 1970-2009. The author uses a panel data methodology based on SUR systems and Wald tests with country specific bootstrap critical values. The results indicate that FDI Granger-causes GDP in only two considered countries and that GDP Granger-causes FDI in four of them. The only third variable the author considers is real exports, which is found to have an impact on both FDI and GDP but only in some of the countries of interest. The study of Li et al. (2011) must also be mentioned. Even if the authors use an inductive directed acyclic graph (DAG) model and not Granger-causality tests, their aim is to analyze the causality between FDI and economic growth while considering additional variables from economic, political and social perspectives (e.g. unemployment, trade, literacy rate, homicide rate, communism social system, …). The authors use cross section data in 2008 and consider 61 developing and 27 developed countries. Their results indicate clearly that local conditions influence both FDI and GDP. Moreover, they indicate that FDI promotes economic growth in developed countries, while economic growth increases FDI inflows in developing economies. The conclusions of this analysis also suggest that the role of FDI in host economies is country-specific or regional specific. Summing up, these studies suggest that the impact of control variables on the relationship between FDI and GDP might be important and thus, that they deserve to be included in the empirical setting (see section 1 for the description of the papers that perform such an investigation).

3. Econometric methodology

3.1 Granger-causality

Granger-causality states that if a series y is better predicted by the complete universe of past information than by that universe less the series x, then x Granger-causes y. In this paper, Granger-causality tests will be performed with panel data, which may present an endogeneity problem due to the dynamic pattern of the data analyses. In order to deal with it, Holtz-Eakin, Newey, and Rosen (1988) proposed a panel VAR model estimated by means of the GMM estimators. This methodology has been further developed by, among others, Arellano and Bond (1991) and Blundell and Bond (1998).

The general dynamic relationship is characterized by the presence of lagged regressors, which include apart from the causality-based variables (*x* and *y*, i.e. FDI or per capita GDP), one (or several) additional control variable(s) (*z*, e.g. infant mortality rate):

$$y_{it} = \sum_{j=1}^{m} \delta_j y_{i,t-j} + \sum_{l=1}^{n} \beta_l x_{i,t-l} + \sum_{k=1}^{r} \gamma_k z_{i,t-k} + u_{it} \tag{1}$$

where $t=1,...,T$ represents time (year) and $i=1,...,N$ denotes the countries. The number of lags, *m*, *n* and *r*, will be assumed finite and shorter than the given time series (see section 3.2 for further details on the optimal lag-length selection's procedure). It is assumed that μ_{it} follows a two-way error component model

$$u_{it} = \mu_i + \lambda_t + \upsilon_{it} \tag{2}$$

where $\mu_i \sim IID(0,\sigma_\mu^2)$ is the unobserved country-specific effect, $\lambda_t \sim IID(0, \sigma_\lambda^2)$ represents period-specific effects and $\upsilon_{it} \sim IID(0,\sigma_\upsilon^2)$ the error term. The dynamic panel data regressions described in (1) and (2) are characterized by two sources of persistence over time: autocorrelation due to the presence of a lagged dependent variable among the regressors and heterogeneity across individuals characterized by the individual effects. According to Granger (1969), in many economic situations, an apparent instantaneous causality would disappear if economic variables were recorded at more frequent time intervals or if the models took account of additional causal variables. So, simultaneity or instantaneous causality may be spurious (meaning instantaneous causality between variables observed at the low frequency without any causality at the high frequency). Thus, here, in order to avoid spurious instantaneous causality, the lags of all right-hand side variables in equation (1) start from 1 and not from 0.

It is important to note that, since y_{it} is a function of μ_i, it follows that $y_{i,t-1}$ is also a function of μ_i. Therefore, $y_{i,t-1}$, a right-hand regressor in (1) is correlated with the error term (problem of endogeneity), which renders the ordinary least squares (OLS) estimator biased and inconsistent even if the υ_{it} are not serially correlated. In this case, it is appropriate to use the Blundell and Bond (1998) GMM estimator to perform these estimates[1] (see Huang, Hwang and Yang, 2008 for a discussion). It combines in a system the regressions in differences with the regressions in levels ("system„ GMM estimator) and use instrumental variables, which are lagged values of the dependent variable, to manage the endogeneity problem described above[2]. The coefficients are robust to the presence of any pattern of heteroskedasticity and of autocorrelation within countries[3]. The test of whether *x* Granger-causes *y* consists of a test of the hypothesis that $\beta_1=\beta_2=...=\beta_n$ are equal to zero (Wald test) after controlling for *y*'s own lags and the influence of additional controls (*z*).

3.2 Lag-length and control variables selection

Results from causality tests are highly sensitive to the order of lags in the autoregressive process. This means that an inadequate choice of the lag-length would lead to inconsistent model estimates. Unfortunately, no single method for choosing the lag-length is ideal in all cases. In this study, the optimal lag-length of the different right-hand side variables is selected according to a specific criterion for GMM estimation, which is the minimization of the MMSC-BIC criterion proposed by Andrews and Lu (2001)[4]. It is able to consistently select the correct model and moments for GMM estimation from a number of different specifications[5]. The MMSC-BIC criterion selects the parameters and the instruments that minimize the following formula:

$$MMSC - BIC = J_i - \log(N)(l_i - k_i) \tag{3}$$

where J_i refers to Hansen test statistic used to test the validity of the over-identifying restrictions evaluated under the specification of model *i*, k_i to the number of parameters to be estimated, l_i to the number of moment conditions under model *i* and *N* to the sample size. This criterion includes bonus terms that reward the use of less parameters

[1] The Blundell and Bond (1998) GMM estimator and not the Arellano and Bond GMM estimator is used because the latter generally suffers from weak instruments, which yields large biases in finite samples and poor precision (lagged values of the levels of the original regressors frequently make weak instruments for the differenced values of the regressors used in the dynamic-panel equation because they may be non-stationary). This is why, to mitigate this problem, a "system„ GMM estimator (from Blundell and Bond 1998), which also use lagged difference instead of the level form as possible instruments in order to solve the statistical problem of unit root or near unit root, seems to be a relatively safe choice (Huang, Hwang and Yang 2008).

[2] The number of instruments cannot be higher than the number of countries (which is equal to 54 in this study) and must be higher or equal to the number of regressors (which varies according to the number of right-hand side variables that are considered and to their respective lag-length).

[3] Option "robust" in Stata.

[4] This criterion is the analogue of the widely used BIC model selection criterion in the sense that it makes the same asymptotic trade-off between the "model fit" and the "number of parameters".

[5] Andrews and Lu (2001) demonstrated that the MMSC-BIC procedure is found to work quite well in a variety of contexts. They also showed that the model and moment selection criterion-Akaike information criterion (MMSC-AIC) is not consistent.

for a given number of moment conditions and thus, the use of more moment conditions for a given number of parameters.

In this lag selection procedure, each autoregressive process is estimated by means of the Blundell and Bond methodology described above and each combination of variables (from 2 to 8) and of lag-length (from 1 to 4) is considered, which corresponds to 500'000 different specifications. The number of instrumental variables must be equal to or higher than the number of right-hand side variables and lower than the number of countries. It is possible to constrain the number of right-hand side variables by limiting the maximal number of the lag-length of the regressors. For this reason, it varies between one and four. As instruments, the most recent lags of the dependent variable are used. The MMSC-BIC criterion is then calculated for each specification, allowing to select the right-hand-side variables and their lag-length.

3.3 Adjusting the number of instruments

Consistency of the GMM estimator depends on the validity of the instruments. Thus, for the selected specification, the instrumental variables selection is submitted to the following standard diagnostic tests. If the instruments do not pass one of these tests, then the specification with the second smallest value of the MMSC-BIC criterion is selected and tested in the same way. The procedure is repeated until the selected specification fulfills all the tests. First, the Hansen test of over-identifying restrictions allows testing the overall validity of the instruments[6]. A second test examines the hypothesis that the error term υ_{it} is not serially correlated. If the errors in levels are serially independent, those in first-differences will exhibit first- but not second-order serial correlation[7] (Arellano, 2003). This corresponds to the AR(1) and AR(2) tests respectively. Finally, despite the fact that system GMM is more robust to weak instruments than the difference estimator, it can also suffer from weak instrument biases[8] (Bazzi and Clemens, 2009). There is no single criterion for evaluating the joint strength of the instrument set of the dynamic panel system GMM estimator (Wintoki, Linck and Netter, 2009). Nevertheless, one possible empirical check suggested by Bond, Hoeffler and Temple (2001), which corresponds to a third diagnostic test of the instruments selection, is to compare estimated panel GMM autoregressive parameters with the empirical bounds implied by the corresponding estimates from OLS (known to be biased upwards) and from simple fixed-effects panel regression (known to be biased downwards).

[6] The null hypothesis is that there is no correlation between the instruments used and the residuals. The reason for using this statistic as opposed to the Sargan statistic, is that it is robust to heteroskedasticity and autocorrelation.

[7] The null hypothesis is that the errors of the first-difference regression do not exhibit second order serial correlation.

[8] The instrumental variables are said to be weak when there is very low correlation between the instrument and the endogenous variable being instrumented. In that case, the model is said to be weakly identified.

Although time-consuming and never used in previous studies, the above-described procedure provides a rigorous basis for the empirical specifications finally selected in the analysis.

4. Empirical results

In this paper, a panel of 54 developed and developing countries is used over the sample period 1980-2013 (see table A.1 in the Appendix A for the list of countries and income groups). Apart from FDI and GDP per capita, six additional control variables are used to reflect economic (inflation, openness to trade, gross fixed capital formation and domestic credits provided by the banking sector) and social conditions (infant mortality rate and primary completion rate). These series' definitions and basic statistics regarding those variables, along with data sources, are listed in Appendix B table B.1. The Fisher unit root test is applied to all the series (first-differenced) in order to ensure that they are stationary[9]

4.1 Whole sample

4.1.1 Selection of control variables and lag-length

As one may choose to include between zero and up to six different control variables, there are 64 basic specifications explaining each of the two dependent variables (FDI and GDP per capita). Taking into account the additional degrees of freedom implied by the number of lags (between one and four for each variable) leads to a total of more than 500'000 different potential specifications. The final specifications have been selected by minimizing the MMSC-BIC criterion according to the procedure described in section 3.2. The final specifications are reported in table 1.

[9] The Fisher unit root test is used because, contrary to the other unit root tests available in the software Stata, it can be applied to series containing gaps, which is the case of the series used in this study. This test's results are listed in Table C.1 in Appendix C.

Table 1: Selected specifications for the whole sample

Dependent variable	Independent variables†		Optimal number of lags†			Min. MMSC-BIC
m	**n**	**r**	**m***	**n***	**r***	
Log(GDP)	FDI ratio	Inflation	1	3	1	-109.9
FDI ratio	*Log(GDP)*	*Domestic credit provided by the banking sector*	*1*	*1*	*2*	*-117.1*

† control variables and lags are optimally selected through the minimisation of the MMSC-BIC criterion over the set of specifications with valid instruments.

The optimal specification explaining the GDP per capita is the one with the explanatory variable inflation and the selected specification for FDI includes domestic credit provided by the banking sector. It is also important to note that the number of lags is not identical for each right-hand-side variables, which reveals that performing a lag-selection process is pertinent.

4.1.2 Global results

Results for the bivariate and selected specifications are reported in table 2. There is no evidence that FDI Granger-causes GDP per capita, even in the bivariate specification. According to the results of the optimal specifications, it seems that inflation in the host country has more impact on GDP than the other economic and social variables considered in this study. This suggests that price stability might be important for the economic development of a country as it creates a safer environment for the various economic actors. The results also indicate that GDP does not Granger-causes FDI. The optimal specification includes domestic credit provided by the banking sector. Even if this variable is not statistically significant, this might suggest that the quality of the financial system is an important condition for the host country in order to attract FDI inflows. As mentioned by Alfaro and al. (2004), well-developed local financial markets might be important for an economy to take advantage of potential FDI spillovers by, for example, lowering costs of conducting transactions and/or ensuring that capital is allocated to projects that yield returns.

Table 2: Blundell and Bond estimates - whole sample

Dependent variable	**Log(GDP)**		**FDI ratio**	
Specification	**Bivariate**	**With controls**	**Bivariate**	**With controls**
LogGDP$_{t-1}$	0.998 *0.000****	0.987 *0.000****	-8.745 *0.483*	0.723 *0.385*
LogGDP$_{t-2}$			8.537 *0.487*	
FDI ratio$_{t-1}$	0.007 *0.241*	0.009 *0.575*	0.607 *0.000****	0.664 *0.007****
FDI ratio$_{t-2}$	-0.005 *0.339*	-0.010 *0.328*		
FDI ratio$_{t-3}$	0.000 *0.950*	0.019 *0.109*		
Inflation$_{t-1}$		0.000 *0.389*		
Domestic credit provided by the banking sector$_{t-1}$				0.061 *0.325*
Domestic credit provided by the banking sector$_{t-2}$				-0.090 *0.177*
Constant	0.036 *0.626*	0.073 *0.270*	1.870 *0.602*	-3.944 *0.549*
Hansen test (p-value)	0.133	0.51	0.250	0.93
First order serial correlation test (p-value)	0.009	0.064	0.002	0.006
Second order serial correlation test (p-value)	0.838	0.157	0.116	0.119
Number of observations	1668	1668	1723	1697
Number of instruments	47	53	49	53

Coefficients of dummy variables are not reported.
p-values in italic
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

The fact that the estimates do not allow to conclude that there is causality between GDP per capita and FDI contradicts most of the studies on this topic. The difficulty to find Granger-causality between these two variables may be explained by the fact that there is no strong macroeconomic relationship between them and suggests that there is rather correlation than causality between FDI and GDP per capita. This result can also be due, among others, to country heterogeneity that is not appropriately captured by the empirical specification. One possible way to control for the latter is to perform the analysis by subgroups according to the level of income of the countries. This is explored in the next section.

4.2 Results by country groups

The objective here is to perform the same analyses as for the whole sample, but at the level of subgroups, in order to control for heterogeneity and to get some more detailed results. Two different subsamples are considered; one contains 22 upper-middle and high income countries and the other one, 32 lower-middle and low income economies[10]. Because of lack of data, it is unfortunately not possible to divide the whole sample into more detailed sub-groups.

As the number of countries in the sub-samples is relatively low in comparison to the number of years, the minimum number of instruments is higher than the number of countries and thus, leads to biased results. One solution to this problem is to reduce the number of time periods in the sample by calculating the arithmetic and non-overlapping average over several years between 1980 and 2013 for each series (see Choe, 2003 for example); in this study, the series are averaged over three years (non-overlapped). This allows using a number of instruments which is lower than the number of countries. However, it must be mentioned that temporal aggregation would generate a loss of dynamic information and might induce an apparent lack of Granger-causality even if one exists (see Herzer, Klasen and Nowak-Lehmann, 2006). But, despite this, this process has the advantage to dilute cyclical influences that can be important in some developing countries. In order to ensure that the number of instrumental variables is higher than the number of regressors, the lag-length of all right-hand side variables in each framework is limited to 1 (which is equivalent to three years). The instrumental variables used in the regressions of these two sub-samples are the lagged dependent variable. In order to be able to compare these additional results with the ones of the whole sample, the same estimations are also performed for the whole sample after having averaged each series over three years (designed as whole sample "averaged").

4.2.1 Selection of control variables

The optimal set of control variables has been identified following the procedure described above. It is different from the optimal specification for the whole sample, which shows that heterogeneity among the different countries and the cyclical variations contained in the series have an influence on the conclusions. The optimal specifications of the whole sample "averaged" and of the two sub-samples are reported in table 3.

[10] The World Bank countries classification of the year 1992 is considered.

Table 3: Selected specifications - whole sample "averaged" and sub-groups

Whole sample "averaged"

Dependent variable	Independent variables†		Min. MMSC-BIC
m	n	r	
Log(GDP)	FDI ratio	Inflation	-32.0
FDI ratio	*Log(GDP)*	-	*-33.4*

† control variables are optimally selected through the minimisation of the MMSC-BIC criterion over the set of specifications with valid instruments.

Upper-middle and high income countries

Dependent variable	Independent variables†		Min. MMSC-BIC
m	n	r	
Log(GDP)	FDI ratio	Inflation	-30.1
FDI ratio	*Log(GDP)*	*Gross fixed capital formation*	*-29.3*

† control variables are optimally selected through the minimisation of the MMSC-BIC criterion over the set of specifications with valid instruments.

Low and lower-middle income countries

Dependent variable	Independent variables†		Min. MMSC-BIC
m	n	r	
Log(GDP)	FDI ratio	Gross fixed capital formation	-32.1
FDI ratio	*Log(GDP)*	-	*-32.7*

† control variables are optimally selected through the minimisation of the MMSC-BIC criterion over the set of specifications with valid instruments.

4.2.2 Whole sample "averaged" and sub-groups results

The whole sample's results (reported in table 4) indicate that FDI positively Granger-causes GDP in the bivariate as well as in the optimal specification. Similarly to the results of section 4.1, the latter includes the variable inflation, which is, however, not statistically significant. When FDI is the dependent variables, the bivariate specification is also the optimal one and FDI is not Granger-caused by GDP. This suggests that FDI is mainly influenced by its own past values rather than by additional explanatory variables.

Table 4: Blundell and Bond estimates - whole sample "averaged"

Dependent variable	**Log(GDP)**		**FDI ratio**
Specification	**Bivariate**	**With controls**	**Bivariate**
LogGDP$_{t-1}$	0.995	0.993	-0.342
	*0.000****	*0.000****	*0.542*
FDI ratio$_{t-1}$	0.047	0.043	0.462
	*0.008****	*0.074**	*0.005****
Inflation$_{t-1}$		0.000	
		0.277	
Constant	-0.065	-0.027	4.603
	0.703	*0.955*	*0.322*
Hansen test (p-value)	0.278	0.453	0.154
First order serial correlation test (p-value)	0.015	0.011	0.004
Second order serial correlation test (p-value)	0.893	0.427	0.510
Number of observations	538	538	539
Number of instruments	27	19	19

Coefficients of dummy variables are not reported.
p-values in italic
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

In the group of high income countries (see table 5), the results indicate that the countries of this sub-group are able to beneficiate from FDI inflows' spillover effects; local firms are advanced enough to learn from foreigners. In the bivariate specification explaining FDI, GDP per capita does not Granger-cause FDI. In the optimal specification, it can be concluded that GDP per capita Granger-causes FDI but only at the 10% level. This specification contains gross fixed capital formation, which is a proxy for domestic investment. The fact that this variable has a negative sign and is statistically significant for this sub-sample might be explained by the fact that these countries are developed enough to finance investments by themselves, so that domestic investment becomes a substitute for FDI, and thus competes with it[11].

[11] According to Lucas (1993), domestic investment may have a positive impact or a negative effect on FDI depending on whether the two variables are substitutes or complements.

Table 5: Blundell and Bond estimates - upper-middle and high income countries subsample

Dependent variable	**Log(GDP)**		**FDI ratio**	
Specification	**Bivariate**	**With controls**	**Bivariate**	**With controls**
LogGDP$_{t-1}$	0.972	0.939	-1.470	-2.915
	*0.000****	*0.000****	*0.510*	*0.090**
FDI ratio$_{t-1}$	0.023	0.022	0.312	0.245
	*0.041***	*0.001****	*0.180*	*0.035***
Inflation$_{t-1}$		-0.004		
		0.469		
Gross fixed capital formation$_{t-1}$				-0.746
				*0.019***
Constant	0.248	0.595	18.137	44.373
	0.389	*0.081**	*0.341*	*0.051**
Hansen test (p-value)	0.355	0.898	0.543	0.800
First order serial correlation test (p-value)	0.068	0.014	0.034	0.054
Second order serial correlation test (p-value)	0.607	0.894	0.514	0.123
Number of observations	220	220	220	219
Number of instruments	19	19	15	19

Coefficients of dummy variables are not reported.
p-values in italic
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

In the case of low income economies (see table 6), the estimates indicate that the optimal GDP per capita specification is the one including gross fixed capital formation and that, like for the subgroup of more developed countries, FDI Granger-causes GDP. This result shows that, even if the level of income of this category of countries might be low, these economies can all the same beneficiate from the spillover effects from FDI (through the creation of jobs or technology transfers for example). The variable gross fixed capital formation is used as a proxy for domestic investment and is statistically significant. It suggests that, in low and lower-middle income countries, domestic investment is positive for economic development, in addition to FDI. However, no Granger-causality can be observed in the bivariate specification. Similarly, there is no Granger-causality from GDP per capita to FDI. Like for the whole sample "averaged", when FDI is the dependent variable, the bivariate specification is also the optimal one.

Table 6: Blundell and Bond estimates - low and lower-middle income countries subsample

Dependent variable	**Log(GDP)**		**FDI ratio**
Specification	**Bivariate**	**With controls**	**Bivariate**
LogGDP$_{t-1}$	0.978 *0.000****	0.956 *0.000****	0.235 *0.682*
FDI ratio$_{t-1}$	0.032 *0.276*	0.046 *0.036***	0.645 *0.000****
Gross fixed capital formation$_{t-1}$		0.012 *0.000****	
Constant	0.124 *0.671*	-0.056 *0.914*	0.147 *0.972*
Hansen test (p-value)	0.295	0.872	0.366
First order serial correlation test (p-value)	0.037	0.033	0.061
Second order serial correlation test (p-value)	0.745	0.735	0.454
Number of observations	318	316	319
Number of instruments	15	19	19

Coefficients of dummy variables are not reported.
p-values in italic
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Summing up, the results show that, for both subgroups of countries, there is Granger-causality from FDI to GDP per capita but that no Granger-causality can be observed from FDI to economic growth. It can also be mentioned that economic and social host country characteristics seem to play a role for the attractiveness of FDI inflows and for economic activity. In particular, the results suggest that domestic investment might displace FDI inflows in upper-middle and high income countries but that it positively influences GDP per capita in low and lower-middle income economies.

5. Summary

In this paper, the Granger-causality link between GDP per capita and FDI has been analyzed for 54 developing and developed countries over the period from 1980 to 2013, by means of a dynamic panel data model based on the Blundell and Bond methodology (system GMM estimator). This analysis provides several improvements with regard to previous studies. In particular, the control variables and the lag-length of the right-hand-side variables have been selected according to a specific procedure, the minimization of the MMSC-BIC criterion, and host country social and economic characteristics have been directly included in the empirical setting. The results demonstrate that host country social and economic conditions might have an impact on GDP per capita and on FDI inflows.

The results reveal that the optimal lag-length is not identical for each explanatory variables and that FDI and GDP per capita are influenced by some local conditions. However, no Granger-causality can be observed between these two variables. If we correct for the cyclical disturbances contained in the series by averaging them over several years, the results are different. They reveal that FDI positively Granger-causes economic growth and that FDI is only influenced by its own past values. The specifications performed for the two sub-samples of countries confirm that there is a positive causal link from FDI to GDP per capita whatever the countries' level of income is. However, no reverse causality can be observed. These results also show that host country local conditions, in particular domestic investment, play a role for the two variables of interest.

Finally, several possible improvements of this study should be enumerated. The link between FDI and economic development might be clarified by taking into account additional host country social and economic characteristics, such as corruption or the importance of the black market for example. The analysis of the short- and long-run relations between GDP per capita and FDI (through ECM, for example) might also be interesting. The use of firm-level instead of or in addition to country-level data might also provide additional evidence on the channels behind the relationship between economic development and foreign investment inflows. It can also be mentioned that, due to the heterogeneity among the countries, the use of panel data models that allow heterogeneous coefficients or of time series could also improve the precision of the results obtained in this analysis. Another possibility would be to enlarge the dataset or to use bootstrap techniques in order to be able to divide the whole sample into more detailed sub-groups. All these additional analyses should improve our understanding of the complex relationship between FDI and GDP per capita.

Appendix A: Countries classification

Table A.1: Countries classification

World Bank 1992 countries classification – Income group			
Low-income economies	**Lower-middle-income economies**	**Upper-middle-income economies**	**High-income economies**
Burkina Faso China Egypt, Arab Rep. Ghana Honduras Indonesia India Mali Malawi Nicaragua Rwanda Sri Lanka Zimbabwe	Algeria Bolivia Chile Congo, Rep. Cote d'Ivoire Costa Rica Dominican Republic Ecuador El Salvador Guatemala Iran, Islamic Rep. Jordan Morocco Paraguay Peru Senegal Swaziland Syrian Arab Republic Thailand Tunisia	Botswana Gabon Greece Korea, Rep. Malaysia Malta Mexico Portugal Saudi Arabia Trinidad and Tobago Uruguay Venezuela, RB	Denmark Finland Germany Iceland Ireland Italy Japan Norway New Zealand Sweden United Arab Emirates
Income group: Economies are divided according to 1992 gross national income (GNI) per capita in US$, calculated using the World Bank Atlas method. The groups are: low income, $675 or less; lower middle income, $676 - $2’695; upper middle income, $2’696 - $8’355; and high income, more than $8’355.			

Source: World Bank, http://www.worldbank.org

Appendix B: Data Definitions and Summary

In this paper, a panel of 54 developed and developing countries is used (see table B.1 for countries classification), over the period from 1980 to 2013. The considered variables are the FDI to GDP ratio, real GDP per capita in (constant 2005) US$ and socioeconomic indicators: openness to trade, gross fixed capital formation, inflation, domestic credit provided by the banking sector, primary completion rate and infant mortality rate. All the variables are made available by the World Bank (World Bank Development Indicators (WDI) 2014) except FDI data and infant mortality rate that come from, respectively, the UNCTAD FDI database and the United Nations Population Division. Countries are selected according to the availability of the different series. Furthermore, in order to avoid FDI round-tripping effects, the offshore centers are excluded from the analyzed economies (see European Central Bank, 2007 and Appendix D, table D.1 for the offshore centers list).

Data definitions

Domestic credit provided by the banking sector (% GDP)

Domestic credit provided by the banking sector is a proxy for the size of the finance sector. It includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net. The banking sector includes monetary authorities and deposit money banks, as well as other banking institutions where data are available (including institutions that do not accept transferable deposits but do incur such liabilities as time and savings deposits). Examples of other banking institutions are savings and mortgage loan institutions and building and loan associations. Source: International Monetary Fund (IMF), International Financial Statistics and data files, and World Bank and OECD GDP estimates.

Exports of goods and services (current US$)

Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

Foreign Direct Investment (FDI)

According to the UNCTAD, a foreign direct investment is an investment involving a long-term relationship and reflecting a lasting interest of a resident entity in one economy (direct investor) in an entity resident in an economy other than that of the investor. The direct investor's purpose is to exert a significant degree of influence on the management of the enterprise resident in the other economy. FDI involves both the initial transaction between the two entities and all subsequent transactions between them and among affiliated enterprises, both incorporated and unincorporated. FDI may be undertaken by individuals, as well as by business entities. Source: http://www.unctad.org.

FDI have three components: equity capital, reinvested earnings and other capital. Equity capital is the foreign direct investor's net purchase of the shares and loans of an enterprise in a country other than its own. Reinvested earnings consist of the part of an affiliate's earnings accruing to the foreign investor that is reinvested in that enterprise. Other capital is short- or long-term loans from parent firms to affiliate enterprises or vice versa. Trade credits, bonds and money market instruments, financial leases and financial derivatives are also included in this component. In the case of banks, deposits, bills and short-term loans are excluded.

Data on FDI flows are on a net basis (capital transactions' credits less debits between direct investors and their foreign affiliates). Net decreases in assets (FDI outward) or net increases in liabilities (FDI inward) are recorded as credits (recorded with a positive sign in the balance of payments), while net increases in assets or net decreases in liabilities are recorded as debits (recorded with a negative sign in the balance of payments). FDI flows with a negative sign (reverse flows) indicate that at least one of the components in the above definition is negative and not offset by positive amounts of the remaining components. These are instances of reverse investment or disinvestment. FDI to GDP ratio is obtained by dividing FDI by nominal GDP.

GDP per capita (constant 2005 US$)

GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. Source: World Bank national accounts data, and OECD National Accounts data files.

Gross fixed capital formation (% GDP)

Gross fixed capital formation (formerly gross domestic fixed investment) is used as proxy for domestic investment. It includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 System National Account (SNA), net acquisitions of valuables are also considered capital formation. Sources: World Bank national accounts data, and OECD National Accounts data files.

Imports of goods and services (current US$)

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

Infant mortality rate per 1,000 live births (quinquennial estimates)

This statistic is generally computed as the ratio of infant deaths (i.e. the deaths of children under one year of age) in a given year to the total number of live births in the same year. Source: United Nations Population's Division.

It is used as proxy for the development of the health system. These are quinquennial estimates. The yearly data are obtained by means of the compound interest formula, which allows inferring the yearly growth rates from the growth rates over five years.

Inflation

GDP deflator (yearly growth rate in %) is used as proxy for macroeconomic stability. Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole and corresponds to the ratio of GDP in current local currency to GDP in constant local currency. Source: World Bank national accounts data, and OECD National Accounts data files.

Openness to trade

Openness to trade is proxied by the percentage of the sum of exports and imports of goods and services on GDP. Exports (imports) of goods and services represent the value of all goods and other market services provided (received) to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments. Source: World Bank national accounts data, and OECD National Accounts data files.

Primary completion rate, total (% of relevant age group)

Primary completion rate is the percentage of students completing the last year of primary school. It is calculated by taking the total number of students in the last grade of primary school, minus the number of repeaters in that grade, divided by the total number of children of official graduation age. It is used as proxy for the level of education. Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics and Department of Statistics. This series contains breaks for most of the countries. The holes between two data are completed by means of the compound interest formula. Missing data at the beginning (end) of the series are extrapolated (interpolated) with the average growth rate calculated from the available data.

Table B.1: Data summary

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max	Source
Foreign direct investment ratio (FDI divided by GDP)	1834	2	4	-23	33	UNCTAD
Real GDP per capita (constant 2005 US$)	1830	9610.4	13637.0	140.3	67804.6	The World Bank
Openness to trade (exports plus imports divided by GDP)	1800	0.7	0.3	0.1	2.2	The World Bank
Inflation (GDP deflator growth rate in %)	1830	38.7	493.7	-29.2	13611.6	The World Bank
Gross fixed capital formation (% of GDP)	1798	21.9	6.3	2.0	59.7	The World Bank
Domestic credit provided by banking sector (% of GDP)	1799	62.1	54.2	-79.1	368.0	The World Bank
Primary completion rate, total (% of relevant age group)	1801	83.8	29.2	9.3	353.1	The World Bank
Infant mortality rate per 1000 live births	1836	3.72E+01	3.25E+01	1.60E+00	1.61E+02	UN

Appendix C: Fisher unit root test

Table C.1: Fisher unit root test

Variable (first differenced)	χ^2-statistics	p-value
Foreign direct investment ratio (FDI divided by GDP)	2545.242	0.000
Real GDP per capita (constant 2005 US$)	866.889	0.000
Openness to trade (exports plus imports divided by GDP)	1654.933	0.000
Inflation (GDP deflator growth rate in %)	2640.243	0.000
Gross fixed capital formation (% of GDP)	1292.515	0.000
Domestic credit provided by banking sector (% of GDP)	1167.487	0.000
Primary completion rate, total (% of relevant age group)	1301.158	0.000
Infant mortality rate per 1000 live births	337.118	0.000

H_0 *: all time series are non-stationary*

H_1 *: at least one series in the panel is stationary*

Appendix D: List of off-shore financial centers

Table D.1: List of off-shore financial centers

Off-shore financial centres[1]
Andorra
Antigua and Barbuda
Anguilla
Netherlands Antilles
Barbados
Bahrain
Bermuda
Bahamas
Belize
Cook Islands
Dominica
Grenada
Guernsey
Gibraltar
Hong Kong
Isle of Man
Jersey
Jamaica
Saint Kitts and Nevis
Cayman Islands
Lebanon
Saint Lucia
Liechtenstein
Liberia
Marshall Islands
Montserrat
Maldives
Nauru
Niue
Panama
Philippines
Singapore
Turks and Caicos Islands
Saint Vincent and the Grenadines
Virgin Islands, British
Virgin Islands, U.S.
Vanuatu
Samoa

[1] Based on Eurostat and OECD list of off-shore financial centres.

Source: European Central Bank Monthly Bulletin, June 2007

Chapter 2
Does trade with China have an impact on African countries' growth?

1. Introduction

Abstracting from the recent global contraction, trade between China and African countries has been booming for about fifteen years. At the same time, robust economic growth has been prevalent in most African countries. Africa's economic performance has been improving since the beginning of the nineties and has even improved in recent years. Has Chinese demand played a role in the acceleration of African output growth? The rapid growth of the Chinese economy has created a strong demand for many of Africa's major export commodities, such as oil and other raw materials, while Africa has clearly benefitted from increased imports of cheap manufactured goods from China. Although Africa's trade with China is relatively modest in comparison to trade with its most important partners (like the EU, for example), it has been growing very rapidly, especially during the last fifteen years. In addition, China's relations with Africa simultaneously intensified in other areas as well, such as FDI, aid and immigration.

Trade does not necessarily translate into an increase in per capita income, as it can generate various and sometimes opposing kinds of effects. On the positive side, trade with China may have improved Africa's terms of trade on two counts. First, cheaper Chinese products have increased the purchasing power of African consumers of manufactured goods. Second, the increasing Chinese demand for African raw materials helps Africa as world prices of commodities have risen. Moreover, by increasing the magnitude of operations in sectors with economies of scale, trade openness may improve overall productivity. On the other hand, trade with China may hurt some African countries through several channels. In the short run, import-competing sectors may struggle with Chinese competition (e.g. Geda and Meskel (2007)), generating unemployment. Furthermore, net importers of raw materials will be hurt by the spike in commodity prices, while net exporters will face more volatile prices, which is a source of economic vulnerability. These different kinds of effects illustrate why the final effect of trade between Africa and China on African growth is not self-evident.

Most of the recent studies on trade between Africa and China have focused on a demand-side decomposition to identify the growth contribution of trade flows. Only a few authors have examined the impact of Chinese trade alone on African growth using econometric models and the results are not clear-cut, which calls for further analyses on this topic. The present study uses panel data econometric models to examine the impact of Chinese trade on African growth for 37 countries from 1985 to 2012. Its aim is to determine whether Chinese-African trade relations are statistically significant and, if so, if they are globally positive or negative for Africa's GDP growth, conditional on other growth determinants.

This study adds to the existing literature by enriching the empirical framework in several ways. First, we consider not only Africa's trade with China and the rest of the world but also trade with Africa's other two main trading partners: the EU and the USA. Second, we control for a number of determinants such as savings or macroeconomic stability, which have been shown to be significant contributors to growth. Third, as trade between Africa and China has been intensifying, a stability test is performed between two different sub-periods. Fourth, a number of alternative specifications are estimated in order to establish the robustness of the analysis.

This paper proceeds as follows. Section 2 provides a review of the literature on trade between China and Africa. Section 3 describes the data and the econometric framework for testing the impact of Chinese trade on Africa's growth, while Section 4 summarizes the empirical findings. Section 5 concludes.

2. Literature survey

We report below the main results of recent studies on the impact of Chinese trade on economic growth in Africa, starting with descriptive studies and following with those relying on econometric analyses.

2.1 Descriptive studies

Chaponniere (2006) describes the development and the structure of trade between Africa and China. He shows that the impact of trade with China on Africa may be different from country to country and that it tends to be positive for economies specialized in the production and exports of raw materials and negative for countries whose production is mainly concentrated in consumption goods. Jenkins and Edwards (2006) determine the main channels through which the main "Asian Drivers" of growth (China and India) are having an effect on sub-Saharan Africa. They evaluate the direct and indirect impacts of both trade and FDI, distinguishing between competitive and complementary effects. Their results suggest that the overall impact on poverty is weak or moderate and varies from country to country. Tull (2006) argues that it is not yet evident that Chinese-African trade will improve Africa's prospects for development because it will not reduce Africa's dependence on a few price-volatile primary goods and the impact on long term sustainable growth is ambiguous. Corkin (2007) examines Chinese multinationals and their activities in different sectors in Africa. Although he does not come to robust conclusions, he observes that the increase in trade between China and Africa could potentially benefit both partners. Asche (2008) analyzes China's relations with Africa through trade, investment, aid and immigration channels. He comes to the conclusion that the overall economic welfare effect remains unclear and that it depends on the African policy response to China's growing influence on the African continent.

2.2 Econometric studies

Chen (2007) considers 46 Sub-Saharan African countries from 1961 to 2005. In order to examine the impact of Chinese trade on economic growth in Africa, the author uses a panel data model and finds evidence suggesting that trade openness with China positively contributes to African growth and this is likely to continue in the future. Giovannetti and Sanfilippo (2009) measure the indirect impact of Chinese trade on African exports. Using disaggregated data for the period 1995-2005 on 48 African countries and a gravity model, they conclude that there is a displacement effect at different levels (sector, product, region and market). They show that Chinese exports have a significant and negative impact on African exports to third markets, including other African countries, and that they are detrimental to local African producers of manufactured goods. Maswana (2009) tests the bivariate causality between growth in Africa and its imports from and its exports to China. He uses quarterly data from 1995 to 2005 for Kenya and South Africa and finds that African exports to China cause economic growth in Africa through technology-embodied capital goods imports. Maswana (2010) considers five African countries over 1980 to 2009. Using a threshold vector error-correction model, he finds that the GDP of African countries that intensively trade with China tends to be rather strongly influenced by China's macroeconomic (positive or negative) development and to move in the same direction. According to the analysis of Yong (2010), which considers, over the period from 1988 to 2005, 47 Sub-Saharan African (SSA) countries, 7 manufacturing sectors and uses a panel data gravity model, imports from China have significant positive impacts on SSA countries' exports of manufactured goods. Adekunle and Wanjiru Gitau (2011) identify various variables that predict trade flows between China and Sub-Saharan Africa using a panel data gravity model for 46 African countries over the period from 1990 to 2008. They find that SSA countries' GDP and the exchange rate help forecast exports to China and that GDP, FDI and the exchange rate are predictors of African imports from China. Baliamoune-Lutz (2011) is the most closely related to the present paper. The author considers North as well as Sub-Saharan African countries from 1995 to 2008. Using dynamic panel data models estimated by the system GMM estimator developed in Blundell and Bond (1998), she focuses on the growth effects of Africa's exports to China and of export concentration. She analyzes the influence on growth of imports from China and of exports to China separately but not taken together. It can also be mentioned that she considers African exports to but not African imports from the rest of the world. Furthermore, the only trading partners of Africa considered in this study are China and the rest of the world. The author finds, among other things, that there is no evidence that exports to China increase growth in Africa unconditionally but that imports from China have a positive impact on African countries' GDP. She also comes to the conclusion that the growth effects of exporting to China are higher for countries that export one major commodity to China than for countries that have more diversified exports.

In sum, the available evidence appears to be inconclusive and this calls for further empirical research.

3. Data and methodology

3.1 Data sources

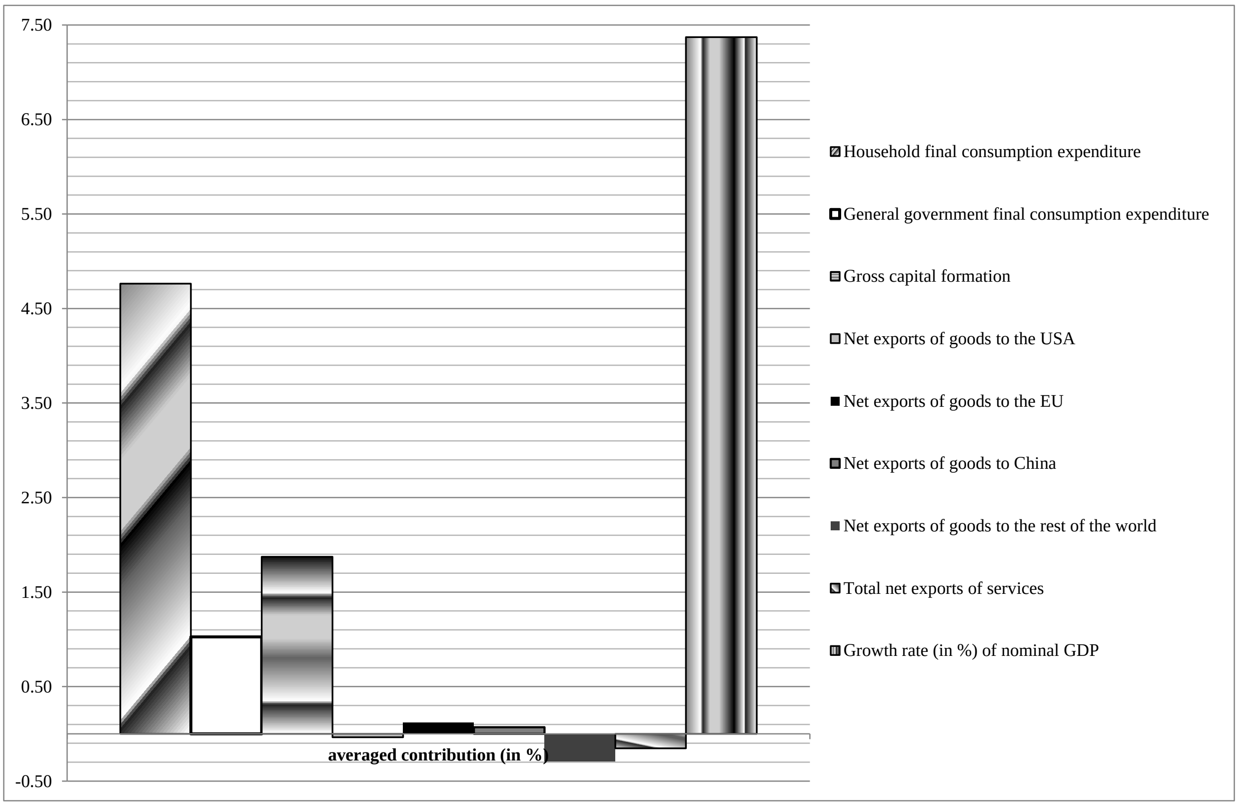
In this paper, a panel of 37 African countries from 1985 to 2012 is used. The variables considered (see Appendix A for data summary and definitions) are imports and exports of merchandise of African countries with selected partners (China, the EU and the USA), total exports and total imports of goods and services, real GDP per capita in (constant 2005) international US dollars (purchasing power parity (PPP)), population, gross domestic savings to GDP ratio, inflation (CPI, as a proxy for macroeconomic stability), external debt to gross national income (GNI) ratio, domestic credit provided by the banking sector to GDP ratio (as a proxy for the development of the financial sector), secondary school enrollment and life expectancy at birth. These data are available from the World Bank (World Development Indicators database) except exports and imports of merchandise, which come from the UNCTAD (merchandise trade matrix) database. Openness to trade is defined as the sum of exports and imports over GDP. These explanatory variables are selected according to growth theory (e.g. Barro and Sala-i-Martin (1995)) as well as to availability, as was the choice of the African countries considered in this analysis. The final panel is unbalanced so the number of observations may change across specifications. Different dummy variables are also included in the specifications; they refer to World Trade Organization (WTO) membership, democracy (data from Freedom House), oil producing countries (members of the African Petroleum Producers' Association) and whether the country is at war (data from the Uppsala Conflict Data Program).

3.2 Descriptive statistics

3.2.1 Contribution of GDP components to GDP growth in African countries

In order to get a general idea of how the impact of trade links with China on economic growth fit into the macroeconomic picture, let us begin by decomposing nominal GDP growth of African countries according to expenditure categories: private consumption, public consumption, final consumption, capital formation, total net exports. The latter will be divided into total net exports of services and net exports of goods to specific destinations (USA, the EU, China and the rest of the world). For each of these aggregates, the contribution to nominal GDP growth is calculated[1]. Due to data availability, the evidence reported here is for a subset of 22 African countries (see Appendix B). The contributions of the different GDP components are calculated for the period from 1985 to 2012 and for two sub-periods, before and after the year 2000. The averaged contributions (over the years and for all considered countries) of the different aggregates are presented in the following figures and detailed results for each country are presented in Appendix B.

Figure 1: Averaged contribution of GDP components to GDP growth

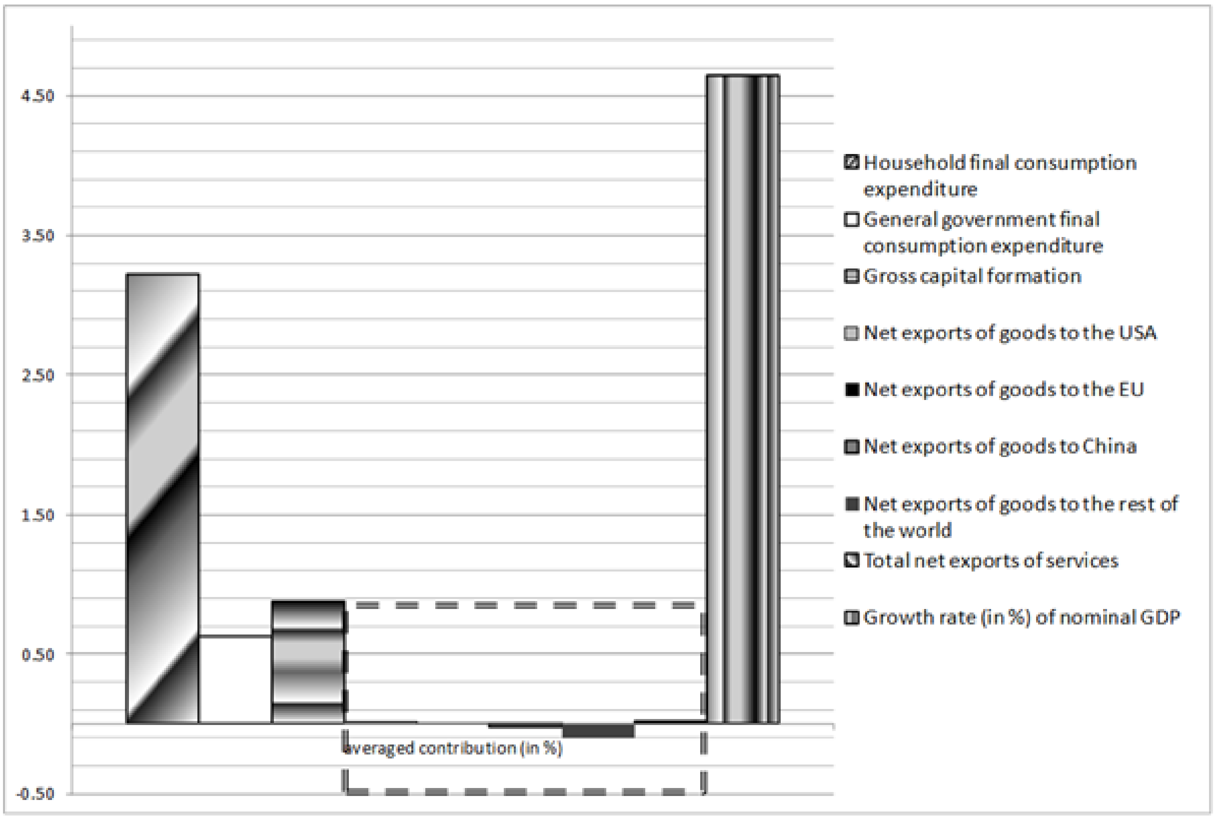


The strongest impulse to nominal GDP growth comes from private consumption (particularly in Ghana). The averaged contributions of government final consumption and of gross capital formation are also positive, while the averaged contribution of net exports is negative but close to zero. This shows that growth in Africa is influenced more by domestic components than by external trade Regarding the contribution of net merchandise exports to China, it is slightly positive (at 0.07%). This suggests that even if trade links between China and Africa are relatively weak, their contribution is not necessarily insignificant or smaller than that of bigger trade partners. Indeed, the results also indicate that, although Africa's merchandise trade with the EU is stronger than with China,

[1] 1. This method allocates imports exclusively to exports. However, it must be noted that imports are also used for domestic expenditures and thus, should also be allocated to all of them. Another method called the "import-adjusted method", allows this allocation (e.g. Kranendonk and Verbruggen (2008)). This methodology is not used in this study because the required data are not available.

its net contribution is only slightly higher than that of Africa's merchandise trade with China (+ 0,05 percentage point).

Figure 2: Averaged contribution of GDP components to GDP growth 1985-1999



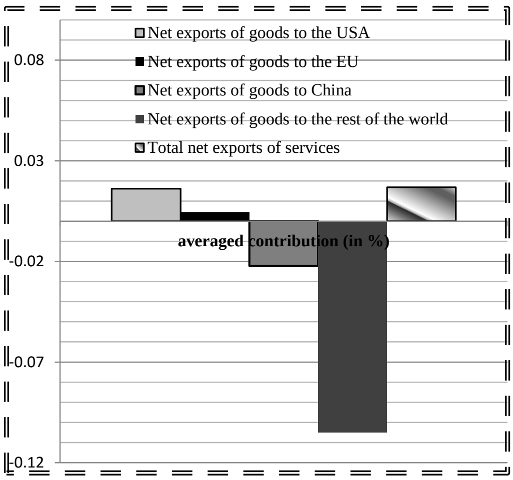
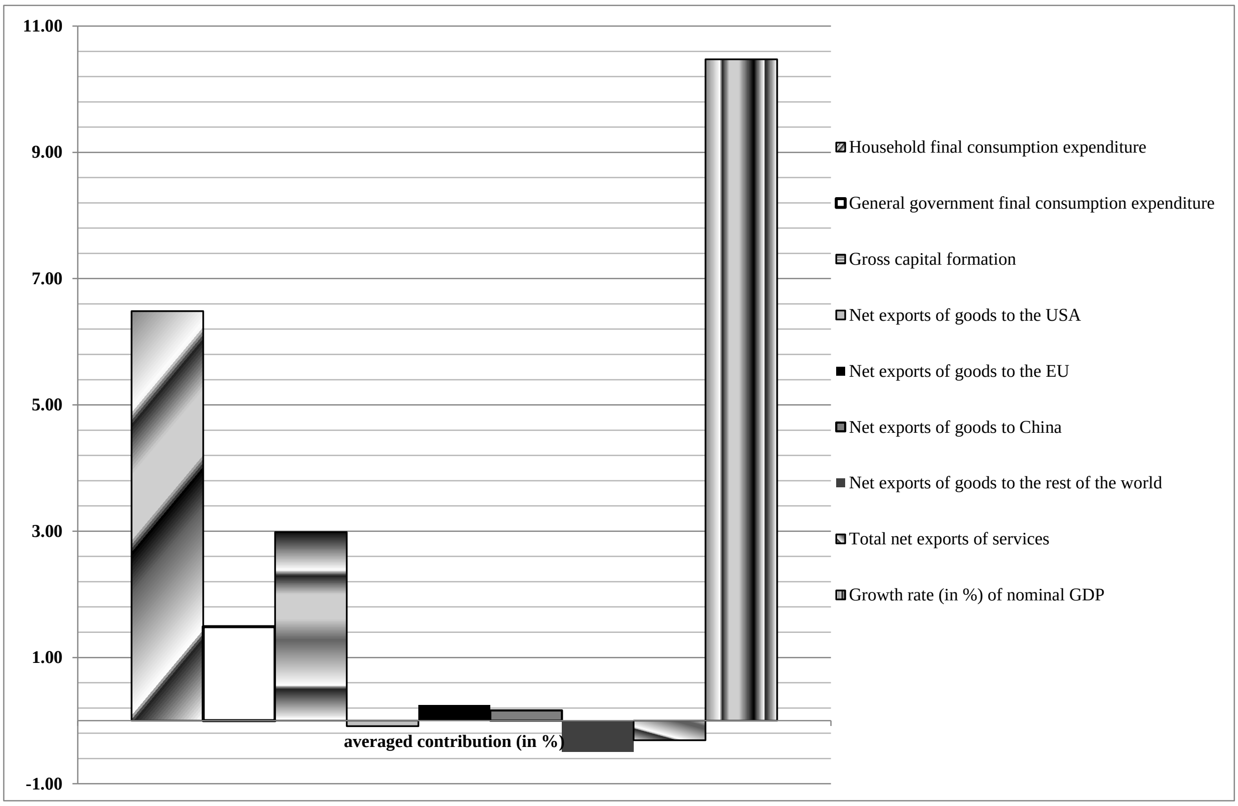


Figure 3: Averaged contribution of GDP components to GDP growth 2000-2012

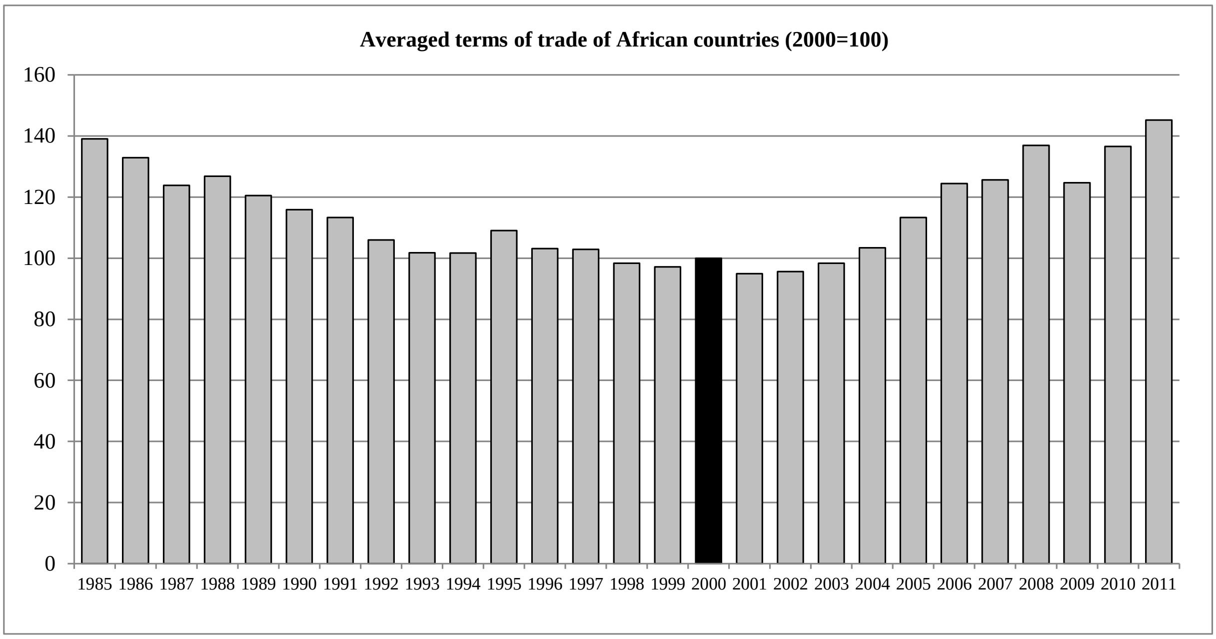


For the sub-period from 1985 to 1999, the conclusions are the same as for the whole period except for the averaged contribution of net merchandise exports to the USA and to China. The effect of the former on growth is now positive and of the latter negative. It can also be noted that the impact of net merchandise exports to the EU is insignificant. The results also suggest that, during this period, net trade had almost no influence on economic growth in Africa. Regarding the contribution of net trade with China, its highest value is only 0.4% (for Gabon, which exports oil and other raw materials to China). The results of the sub-period from 2000 to 2012 also lead to the same conclusions but the levels of the different aggregates' contributions are now amplified. The growth rate of nominal GDP is more than two times higher between 2000 to 2012 than between 1985 to 1999 and the averaged contribution of net merchandise exports to China, even if it remains close to zero, is eight times higher in absolute value (its maximal value is 6.5% and concerns the Congo Republic). It must also be noted that the contribution of net merchandise exports to China becomes positive and that of net merchandise exports to the USA, negative. The results also suggest that, during the last decade of the period under consideration, the influence of trade with China on economic growth in Africa increased noticeably.

3.2.2 Development in terms of trade in African countries

As mentioned before, one possible effect of trade with China in Africa might be an improvement of African terms of trade that would be generated through, on the one hand, an increase of the purchasing power of African consumers of manufactured goods and, on the other hand, a rise of the Chinese demand for African raw materials. The development of averaged terms of trade (over the 37 countries considered in this study) between 1985 and 2011 is presented in the following figure[2].

Figure 4: Development in terms of trade in African countries



Source: Net barter terms of trade, World Development Indicators, World Bank

Since 1985, averaged terms of trade in Africa have been progressively deteriorating till the end of the nineties. From 2002, it started to increase more and more and its value was even higher than 145 in 2011. However, this development was not totally smooth as terms of trade fell between 2008 and 2009. This can be attributed to the global financial crisis, as explained by Anyanwu (2011). It must also be mentioned that terms of trade did not evolve in the same way in all countries as it depends on the kind of goods that are imported and exported by each country. For example, since 2000, the terms of trade of Togo has been decreasing. In Rwanda, the terms of trade were worse than the averaged value till the middle of the nineties but they tended to improve during the whole period under consideration and ultimately reached more than 225 in 2011.

[2] The series of terms of trade for each country are available from the author upon request.

3.3 Econometric specification and control variables

The growth regression approach is widely used to identify major determinants of growth. It starts with an aggregate production function, which is augmented with several conditioning variables aiming at capturing the effects of total factor productivity growth. The production function is then converted into growth rates before estimation. As mentioned by Sala-i-Martin et al. (2004), growth theories are not explicit enough about what explanatory variables belong in the growth regression. The multiplicity of possible regressors is one of the major difficulties faced by empirical researchers. In this study, the explanatory variables are selected according to growth theories (e.g. Barro and Sala-i-Martin (1995)). According to the latter, the core growth determinants are initial income, investment, school enrollment and population. Additional explanatory variables, such as openness to trade, inflation and external debt for example, are then added to the basic set of explanatory variables. As stressed in Johnson (2006), since any theory can suggest only one model of economic growth, it is reasonable to try several different specifications.

In order to analyze the impact of trade with China on Africa's economic growth, the following basic growth equation is used:

$$GDP_{i,t} = \alpha_i + \beta_1 (ott)_{i,t-1} + \beta_2 X_{i,t-1} + \beta_3 D_{i,t} + \mu_t + \varepsilon_{i,t} \quad (1)$$

All variables except dummies are expressed in logs and are first-differenced. The term α_i represents country effects and controls for any persistent differences across countries, such as initial conditions, different levels of technical know-how or cultural differences. Regarding the variables, *GDP* is the first difference of real per capita GDP in PPP and *ott* is openness to trade (exports plus imports over GDP). Not only total openness to trade is considered but also openness to merchandise trade[3] with the EU, with the USA, with China and with the rest of the world. Additional control variables, such as school enrollment, inflation or population are represented by *X*. The latter also includes initial GDP, in accordance to the conditional convergence argument (e.g. Barro (2003)), which will be considered in robustness tests. The variable *D* refers to dummy variables; they are also included in the set of specifications to execute robustness tests. In addition, it is not unreasonable to believe that there have been general trends over time not captured in the other variables. Thus, a trend (μ_t) is added to this model to control for such an effect. Finally, the coefficient $\varepsilon_{i,t}$ represents disturbances that are assumed to be serially uncorrelated. Annual and not yearly averaged data are used for these estimations; even if temporal aggregation would allow a reduction in

[3] Data on African trade among various economic partners are only available for merchandise (and not for services).

cyclical variation, it would generate a loss of dynamic information (see, for example, Rossana and Seater (1995)). Nevertheless, the specifications will also be estimated with yearly averaged data as an additional robustness test.

4. Empirical results

The model described in the previous section is estimated by the within estimator, which implies that OLS is performed on the mean-differenced data, and the standard errors are robust to heteroskedasticity. The Fisher unit root test is applied to all the series (in log and first-differenced) in order to ensure that they are stationary[4] and the presence of individual effects is confirmed by the F test. Furthermore, a Hausman test indicates that fixed effects are more appropriate than random effects[5]. Finally, an endogeneity test (another Hausman test) is performed for each right hand side variable and shows that none of these variables suffer from this problem[6]. It must also be noted that the R-squared reported with panel-data models is, in general, relatively low because it is obtained by only fitting a mean deviated model where the explanatory effects of the groups[7] are not considered. In this study, R-squared has been adjusted in order to take into account these effects, by estimating each dummy variable for the groups.

4.1 General results

4.1.1 Specifications with total openness to trade

The results of the growth equation with total openness to trade are presented in the following table:

[4] The Fisher unit root test is used because, contrary to the other unit root tests available in Stata, it can be applied to series containing gaps, which is the case of the series used in this study.
[5] The null hypothesis of this Hausman test is that the unobserved effect is uncorrelated with the explanatory variables (i.e. random effects are consistent).
[6] The results of all these tests are available from the author upon request.
[7] In this study, the groups correspond to the African countries.

Table 1: Growth equation's results -total openness to trade

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade	0.034	0.031	0.034	0.031	0.056	0.056	0.052
	*0.042***	*0.041***	*0.040***	*0.039***	*0.000****	*0.001****	*0.002****
School enrollment, secondary	0.025	0.018	0.023	0.015	0.020	0.019	0.005
(%)	*0.445*	*0.591*	*0.473*	*0.655*	*0.482*	*0.508*	*0.837*
Population	-0.393	-0.303	-0.473	-0.382	-0.487	-0.519	-0.597
	0.165	*0.352*	*0.112*	*0.262*	*0.124*	*0.114*	*0.096**
Gross domestic savings	0.005	0.007	0.005	0.007	0.007	0.007	0.005
(GDP ratio)	*0.079**	*0.022***	*0.082**	*0.023***	*0.030***	*0.032***	*0.064**
Inflation		-0.038		-0.037	-0.038	-0.038	-0.028
		*0.004****		*0.004****	*0.003****	*0.003****	*0.001****
Life expectancy at birth, total			0.249	0.216		0.113	0.163
(years)			*0.017***	*0.059**		*0.331*	*0.201*
External debt					-0.054	-0.054	-0.055
(GNI ratio)					*0.000****	*0.000****	*0.000****
Domestic credit provided by banking sector							-0.004
(GDP ratio)							*0.372*
Constant	0.052	0.047	0.027	0.018	-0.034	-0.033	-0.040
	*0.000****	*0.000****	*0.139*	*0.187*	*0.161*	*0.184*	*0.113*
Observations	698	650	691	644	558	558	506
Number of countries	35	35	35	35	33	33	32
R-squared	0.39	0.44	0.39	0.44	0.43	0.43	0.48

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

The results imply that total openness to trade has a positive impact on economic growth, which suggests that trade openness (through specialization and economies of scale) may increase productivity and thus economic growth. The coefficient of secondary school enrollment is not significantly different from zero. This runs contrary to the results of most studies, which suggest that more highly-skilled workers are beneficial to economic growth. This might be due to the fact that, in Africa, economic growth comes mainly from increasing development of the exploitation of natural resources, which is capital and not labor intensive and thus does not require more highly-skilled workers. Regarding population, its coefficient is not significantly different from zero and negative. This indicates that an increase of population would tend to be harmful for output per capita through, for instance, a decrease of capital per worker that might generate a decline in productivity. The coefficient of gross domestic savings is significantly different from zero and positive, which can be attributed, among other things, to higher investment in infrastructure. The coefficient of inflation is significantly different from zero and negative, which confirms that a stable macroeconomic environment attracts investors and is favorable for economic growth in Africa. Another result is that the impact on growth of life expectancy is positive and statistically significant, but only in two specifications (out of four). This suggests that better health tends to increase economic growth but also that this effect is relatively weak in Africa. The results also indicate that the external debt to GNI ratio has a significant and detrimental impact on GDP growth (because it may induce, for example, an increase in country risk or higher interest rates). The coefficient of domestic credit providing by the banking sector, used as a proxy for the development of the financial sector, is not significantly different from zero. This shows that, in Africa, the financial sector is not developed and efficient enough in order to be beneficial for economic growth.

4.1.2 Specifications with openness to trade with China, with the EU, with the USA and with the rest of the world

In the following set of specifications (denoted hereafter as "the basic set of specifications"), openness to merchandise trade is divided into openness to trade with China, with the EU, with the USA and with the rest of the world (see Table 2).

Table 2: Growth equation's results - openness to trade with China, with the EU, with the USA and with the rest of the world

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.005	-0.004	-0.005	-0.004	0.003	0.003	0.001
	0.386	*0.511*	*0.418*	*0.490*	*0.517*	*0.563*	*0.779*
Openness to trade with EU	0.009	0.005	0.010	0.006	0.031	0.032	0.029
	0.476	*0.653*	*0.472*	*0.637*	*0.024***	*0.019***	*0.017***
Openness to trade with the rest of the world	0.013	0.014	0.013	0.015	0.017	0.017	0.016
	*0.030***	*0.021***	*0.027***	*0.019***	*0.009****	*0.008****	*0.017***
Openness to trade with China	0.006	0.006	0.006	0.006	0.006	0.006	0.009
	0.175	*0.209*	*0.171*	*0.206*	*0.142*	*0.137*	*0.037***
School enrollment, secondary	0.019	0.017	0.020	0.018	0.025	0.027	0.010
(%)	*0.570*	*0.626*	*0.557*	*0.611*	*0.388*	*0.361*	*0.710*
Population	-0.364	-0.289	-0.273	-0.196	-0.493	-0.382	-0.429
	0.253	*0.387*	*0.263*	*0.428*	*0.100*	*0.073**	*0.067**
Gross domestic savings	0.006	0.007	0.006	0.007	0.006	0.006	0.005
(GDP ratio)	*0.060**	*0.023***	*0.070**	*0.027***	*0.055**	*0.064**	*0.118*
Inflation		-0.037		-0.037	-0.038	-0.038	-0.027
		*0.004****		*0.004****	*0.003****	*0.003****	*0.001****
Life expectancy at birth, total			-0.086	-0.087		-0.112	-0.107
(years)			*0.398*	*0.431*		*0.285*	*0.334*
External debt					-0.055	-0.058	-0.058
(GNI ratio)					*0.000****	*0.000****	*0.000****
Domestic credit provided by banking sector							-0.003
(GDP ratio)							*0.616*
Constant	0.048	0.044	0.028	0.024	-0.025	-0.031	-0.035
	*0.000****	*0.000****	*0.088**	*0.143*	*0.285*	*0.186*	*0.157*
Observations	667	626	658	618	542	540	488
Number of countries	35	35	35	35	33	33	32
R-squared	0.40	0.45	0.40	0.45	0.44	0.45	0.50

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Openness to trade with the EU and with the rest of the world have both a positive and significant impact on African economic growth. However, the coefficients of trade relations with the USA and with China are not statistically significant. Regarding the other explanatory variables, the results lead to the same conclusions as those from the specifications with total openness to trade.

Openness to trade with the rest of the world has a positive and significant impact on African economic growth. This is also the case of openness to trade with the EU, though not in all specifications, whereas the coefficients of trade relations with the USA and with China are not statistically significant. Regarding the other explanatory variables, the results lead to similar conclusions to those from the specifications with total openness to trade. The fact that the coefficient of African trade with China is not significantly different from zero may be explained by the fact that the sample period is too long; as relations between China and Africa have become stronger during the beginning of the current century, it seems appropriate to divide the sample into two parts in order to isolate the results from the final decade of the period under consideration. Thus, the sample is split in two in the year 2000. The choice of this year is confirmed by the Chow test, which indicates that the coefficient of openness to trade with China is not identical before and after the year 2000. The results from these two sub-samples are presented in Tables 3 and 4.

Table 3: Growth equation's results 1985-1999 - openness to trade with China, with the EU, with the USA and with the rest of the world

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.019	-0.020	-0.019	-0.020	-0.003	-0.003	-0.005
	*0.045***	*0.043***	*0.041***	*0.040***	*0.546*	*0.504*	*0.391*
Openness to trade with EU	0.022	0.020	0.022	0.019	0.051	0.051	0.041
	0.188	*0.223*	*0.191*	*0.230*	*0.013***	*0.013***	*0.033***
Openness to trade with the rest of the world	0.011	0.012	0.012	0.013	0.020	0.021	0.016
	0.171	*0.154*	*0.148*	*0.133*	*0.014***	*0.012***	*0.034***
Openness to trade with China	0.000	0.000	0.000	0.000	0.003	0.003	0.003
	0.968	*0.945*	*0.956*	*0.929*	*0.517*	*0.517*	*0.335*
School enrollment, secondary	0.017	0.054	0.016	0.055	0.055	0.056	0.029
(%)	*0.697*	*0.294*	*0.722*	*0.290*	*0.256*	*0.250*	*0.565*
Population	-0.826	-0.677	-0.717	-0.564	-0.666	-0.571	-0.523
	*0.019***	*0.056**	*0.010***	*0.030***	*0.039***	*0.020***	*0.034***
Gross domestic savings	0.000	0.002	0.000	0.001	0.001	0.001	0.000
(GDP ratio)	*0.917*	*0.637*	*0.991*	*0.731*	*0.750*	*0.838*	*0.966*
Inflation		-0.027		-0.027	-0.025	-0.025	-0.022
		*0.041***		*0.044***	*0.022***	*0.024***	*0.013***
Life expectancy at birth, total			-0.130	-0.133		-0.111	-0.149
(years)			*0.161*	*0.177*		*0.264*	*0.187*
External debt					-0.077	-0.077	-0.072
(GNI ratio)					*0.000****	*0.000****	*0.000****
Domestic credit provided by banking sector							-0.008
(GDP ratio)							*0.312*
Constant	0.001	0.027	-0.002	0.024	0.034	0.031	-0.010
	0.950	*0.050**	*0.891*	*0.042***	*0.008****	*0.004****	*0.436*
Observations	371	340	371	340	333	333	306
Number of countries	35	33	35	33	32	32	31
R-squared	0.49	0.53	0.50	0.53	0.46	0.46	0.44

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

The conclusions from the results of the first sub-period of the sample are slightly different from those obtained from the whole sample. It can be noted that, using this set of specifications, gross domestic savings has no impact on African GDP. This might be due to the fact that during this period domestic savings in Africa was not high enough to finance investment. Another difference concerns the coefficient of population. It is now clearly statistically significant, which shows that an increase of population is detrimental to per capita economic growth in Africa. As mentioned before, this suggests that population growth may generate a decrease of capital per worker and, thus, of capital productivity. During this sub-period, the coefficient of openness to trade with the USA is negative and the one of openness to trade with China is, like in the whole sample, not significant. Regarding openness to trade with the rest of the world, its impact on growth in Africa is less obvious than in the whole sample as it is statistically significant in only three specifications.

Table 4: Growth equation's results 2000-2012 - openness to trade with China, with the EU, with the USA and with the rest of the world

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.002	0.004	0.003	0.004	0.001	0.000	-0.003
	0.798	*0.622*	*0.733*	*0.623*	*0.879*	*0.967*	*0.695*
Openness to trade with EU	-0.005	-0.003	-0.005	-0.002	0.035	0.038	0.034
	0.794	*0.871*	*0.814*	*0.907*	*0.087**	*0.074**	*0.079**
Openness to trade with the rest of the world	0.020	0.022	0.020	0.022	0.024	0.024	0.026
	*0.034***	*0.035***	*0.036***	*0.038***	*0.016***	*0.019***	*0.035***
Openness to trade with China	0.027	0.027	0.027	0.027	0.030	0.031	0.028
	*0.037***	*0.033***	*0.035***	*0.032***	*0.020***	*0.018***	*0.045***
School enrollment, secondary	-0.069	-0.061	-0.071	-0.063	0.001	0.000	-0.047
(%)	*0.248*	*0.334*	*0.255*	*0.342*	*0.984*	*0.998*	*0.357*
Population	0.274	0.017	0.395	0.110	-0.985	-0.930	0.241
	0.854	*0.992*	*0.794*	*0.950*	*0.505*	*0.545*	*0.861*
Gross domestic savings	0.017	0.017	0.017	0.017	0.024	0.024	0.024
(GDP ratio)	*0.001****	*0.002****	*0.002****	*0.002****	*0.000****	*0.000****	*0.000****
Inflation		-0.013		-0.013	-0.070	-0.069	-0.076
		0.579		*0.584*	*0.003****	*0.003****	*0.284*
Life expectancy at birth, total			-0.105	-0.094		-0.175	-0.084
(years)			*0.666*	*0.740*		*0.568*	*0.743*
External debt					-0.031	-0.036	-0.042
(GNI ratio)					*0.062**	*0.038***	*0.011***
Domestic credit provided by banking sector							0.000
(GDP ratio)							*0.966*
Constant	-0.004	0.026	-0.001	0.001	-0.007	0.247	0.034
	0.920	*0.570*	*0.982*	*0.980*	*0.900*	*0.000****	*0.314*
Observations	272	264	263	256	187	185	163
Number of countries	34	34	34	34	32	32	30
R-squared	0.44	0.46	0.44	0.46	0.56	0.56	0.70

All variables except dummies are expressed in log and are first-differenced
Robust p values in italics
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

In the second sub-period, the specifications' results present a different picture. Openness to trade with China now has a positive and significant (at the 1% level) impact on African economic growth and the coefficient of openness to trade with the EU is still statistically significant but only in three specifications and only at the 10% level. This suggests that a substitution effect between trade with the EU and trade with China may have taken place in Africa during this sub-period. It can also be noted that African trade relations with the USA have no impact on economic growth in Africa. The results of the second sub-period also show that the coefficient of trade with the rest of the world is statistically significant and positive and that the impact on African growth of gross domestic savings has been positive. This can be attributed to the financing of investment, which generated an increase in the productivity of capital and thus, in economic growth. As in the whole sample and in the first sub-period, inflation and external debt both have a significant and negative impact on GDP growth in Africa, as expected, and the coefficients of the remaining explanatory variables are not significantly different from zero.

4.1.3 Specifications for different groups of countries

In order to better understand the channels through which trade influences economic growth of African countries, the latter are grouped according to the commodities they export most. For this purpose, the basic set of specifications is estimated for three different groups of countries that are major exporters of "Petroleum, petroleum products and related materials", of "Metalliferous ores and metal scrap" and of "Cork and wood"[8]. The same estimations are also performed for the eight countries of the sample that have the highest real GDP per capita[9].

Table 5: Growth equation's results 1985-1999 - major exporters of petroleum, petroleum products and related materials

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.044	-0.042	-0.044	-0.042	0.005	0.007	0.004
	*0.078**	*0.090**	*0.079**	*0.096**	*0.738*	*0.671*	*0.802*
Openness to trade with EU	0.024	0.011	0.024	0.016	0.056	0.065	0.007
	0.459	*0.727*	*0.466*	*0.654*	*0.279*	*0.206*	*0.840*
Openness to trade with the rest of the world	0.030	0.034	0.030	0.035	0.030	0.030	0.021
	*0.027***	*0.022***	*0.027***	*0.017***	*0.108*	*0.087**	*0.208*
Openness to trade with China	0.002	0.001	0.002	0.001	0.004	0.005	0.011
	0.845	*0.958*	*0.846*	*0.932*	*0.657*	*0.584*	*0.125*
School enrollment, secondary	-0.112	-0.003	-0.119	0.058	-0.189	-0.104	-0.172
(%)	*0.373*	*0.987*	*0.435*	*0.797*	*0.281*	*0.599*	*0.300*
Population	-1.438	-1.094	-1.385	-1.663	-1.571	-2.420	-3.341
	*0.088**	*0.677*	*0.159*	*0.553*	*0.527*	*0.358*	*0.192*
Gross domestic savings	0.004	0.012	0.004	0.012	0.001	0.001	0.006
(GDP ratio)	*0.768*	*0.263*	*0.771*	*0.257*	*0.894*	*0.917*	*0.455*
Inflation		-0.029		-0.027	-0.021	-0.017	-0.011
		0.107		*0.126*	*0.107*	*0.150*	*0.287*
Life expectancy at birth, total			-0.166	1.975		3.060	-0.137
(years)			*0.909*	*0.439*		*0.183*	*0.955*
External debt					-0.122	-0.128	-0.096
(GNI ratio)					*0.026***	*0.017***	*0.044***
Domestic credit provided by banking sector							-0.012
(GDP ratio)							*0.393*
Constant	-0.007	0.038	-0.009	0.052	0.052	0.074	0.082
	0.854	*0.587*	*0.837*	*0.493*	*0.420*	*0.296*	*0.207*
Observations	123	103	123	103	99	99	94
Number of countries	11	10	11	10	9	9	9
R-squared	0.63	0.69	0.63	0.69	0.56	0.58	0.60

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

[8] Major exporters of "Petroleum, petroleum products and related materials": Angola, Algeria, Cameroon, Chad, Congo, Rep. , Congo, Dem. Rep. , Equatorial Guinea, Gabon, Ghana, Guinea and Mauritania; major exporters of "Metalliferous ores and metal scrap": Congo, Dem. Rep. , Ethiopia, Gabon, Ghana, Madagascar, Mauritania, Namibia, South Africa and Zambia; major exporters of "Cork and wood": Cameroon, Congo, Rep. , Congo, Dem. Rep. , Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Liberia, Mozambique, South Africa and Togo.

[9] These countries are: Gabon, Equatorial Guinea, Botswana, South Africa, Namibia, Tunisia and Algeria.

Table 6: Growth equation's results 2000-2012 - major exporters of petroleum, petroleum products and related materials

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.018	0.023	0.019	0.019	0.028	0.029	-0.016
	0.347	*0.313*	*0.369*	*0.389*	*0.202*	*0.197*	*0.337*
Openness to trade with EU	-0.016	-0.021	-0.010	-0.011	0.081	0.083	0.024
	0.727	*0.657*	*0.856*	*0.836*	*0.095**	*0.065**	*0.382*
Openness to trade with the rest of the world	0.016	0.016	0.017	0.017	0.004	0.002	-0.003
	0.221	*0.229*	*0.195*	*0.204*	*0.803*	*0.916*	*0.765*
Openness to trade with China	0.043	0.041	0.045	0.042	0.036	0.037	0.037
	*0.000****	*0.001****	*0.000****	*0.000****	*0.010***	*0.007****	*0.000****
School enrollment, secondary	-0.110	-0.105	-0.084	-0.073	-0.010	0.003	-0.128
(%)	*0.483*	*0.534*	*0.616*	*0.688*	*0.940*	*0.979*	*0.104*
Population	4.481	3.436	4.601	3.328	-2.844	-2.794	21.587
	0.197	*0.513*	*0.182*	*0.513*	*0.699*	*0.704*	*0.001****
Gross domestic savings	0.027	0.026	0.024	0.027	0.062	0.053	0.051
(GDP ratio)	*0.048***	*0.068**	*0.080**	*0.057**	*0.028***	*0.069**	*0.125*
Inflation		-0.013		0.004	-0.070	-0.038	-0.176
		0.687		*0.898*	*0.076**	*0.253*	*0.024***
Life expectancy at birth, total			-3.392	-3.898		-4.432	-1.942
(years)			*0.129*	*0.121*		*0.153*	*0.612*
External debt					-0.011	-0.013	-0.009
(GNI ratio)					*0.750*	*0.712*	*0.752*
Domestic credit provided by banking sector							0.002
(GDP ratio)							*0.805*
Constant	-0.054	-0.078	-0.089	-0.055	0.009	0.035	-0.495
	0.575	*0.571*	*0.345*	*0.692*	*0.967*	*0.871*	*0.001****
Observations	98	92	95	90	61	61	49
Number of countries	11	11	11	11	10	10	9
R-squared	0.54	0.55	0.55	0.56	0.71	0.73	0.92

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 7: Growth equation's results 1985-1999 - major exporters of metalliferous ores and metal scrap

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.024	-0.029	-0.024	-0.029	-0.024	-0.023	-0.027
	0.103	*0.065**	*0.131*	*0.078**	*0.121*	*0.140*	*0.131*
Openness to trade with EU	0.028	0.024	0.029	0.025	0.048	0.051	0.050
	0.320	*0.420*	*0.308*	*0.388*	*0.243*	*0.204*	*0.231*
Openness to trade with the rest of the world	0.052	0.049	0.052	0.049	0.053	0.054	0.054
	*0.001****	*0.002****	*0.001****	*0.002****	*0.002****	*0.002****	*0.014***
Openness to trade with China	0.009	0.013	0.009	0.013	0.012	0.011	0.011
	0.190	*0.097**	*0.220*	*0.106*	*0.124*	*0.137*	*0.159*
School enrollment, secondary	0.039	0.072	0.041	0.077	0.065	0.073	0.094
(%)	*0.725*	*0.537*	*0.709*	*0.503*	*0.591*	*0.541*	*0.471*
Population	-4.093	-3.320	-4.176	-3.605	-3.138	-3.540	-2.025
	*0.034***	*0.167*	*0.036***	*0.186*	*0.201*	*0.207*	*0.546*
Gross domestic savings	0.007	0.007	0.007	0.007	0.006	0.007	0.006
(GDP ratio)	*0.158*	*0.145*	*0.153*	*0.138*	*0.151*	*0.141*	*0.380*
Inflation		-0.007		-0.005	-0.008	-0.006	-0.010
		0.503		*0.644*	*0.391*	*0.555*	*0.417*
Life expectancy at birth, total			0.201	0.311		0.418	0.410
(years)			*0.828*	*0.765*		*0.687*	*0.688*
External debt					-0.051	-0.052	-0.053
(GNI ratio)					*0.123*	*0.109*	*0.116*
Domestic credit provided by banking sector							-0.014
(GDP ratio)							*0.501*
Constant	0.094	0.059	0.096	0.067	0.054	0.065	0.048
	*0.085**	*0.417*	*0.091**	*0.403*	*0.464*	*0.425*	*0.621*
Observations	102	95	102	95	94	94	91
Number of countries	9	8	9	8	8	8	8
R-squared	0.49	0.52	0.49	0.52	0.53	0.53	0.53

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 8: Growth equation's results 2000-2012 - major exporters of metalliferous ores and metal scrap

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.015	-0.012	-0.013	-0.009	-0.019	-0.017	-0.020
	0.249	*0.576*	*0.392*	*0.656*	*0.191*	*0.292*	*0.260*
Openness to trade with EU	0.012	0.021	0.006	0.019	0.067	0.070	0.078
	0.611	*0.460*	*0.810*	*0.472*	*0.035*****	*0.027*****	*0.051**
Openness to trade with the rest of the world	0.022	0.023	0.022	0.023	0.036	0.037	0.039
	0.294	*0.241*	*0.260*	*0.177*	*0.014*****	*0.009******	*0.009******
Openness to trade with China	0.004	0.002	0.004	0.010	0.026	0.027	0.025
	0.839	*0.923*	*0.823*	*0.639*	*0.321*	*0.317*	*0.400*
School enrollment, secondary	0.072	0.078	0.085	0.100	0.117	0.107	0.129
(%)	*0.461*	*0.454*	*0.361*	*0.302*	*0.334*	*0.368*	*0.407*
Population	-1.497	-1.512	-3.456	-3.725	-6.624	-7.904	-7.821
	0.675	*0.635*	*0.345*	*0.272*	*0.036*****	*0.032*****	*0.061**
Gross domestic savings	0.016	0.018	0.016	0.017	0.027	0.026	0.032
(GDP ratio)	*0.108*	*0.064**	*0.104*	*0.061**	*0.039*****	*0.045*****	*0.124*
Inflation		-0.001		-0.002	-0.071	-0.072	-0.037
		0.958		*0.941*	*0.001******	*0.000******	*0.794*
Life expectancy at birth, total			-1.176	-1.635		-0.942	-0.953
(years)			*0.135*	*0.060**		*0.397*	*0.456*
External debt					-0.039	-0.038	-0.034
(GNI ratio)					*0.122*	*0.135*	*0.270*
Domestic credit provided by banking sector							-0.003
(GDP ratio)							*0.748*
Constant	0.053	0.026	0.107	0.121	0.125	0.167	0.242
	0.496	*0.697*	*0.203*	*0.132*	*0.172*	*0.097**	*0.017*****
Observations	76	72	74	71	53	53	48
Number of countries	9	9	9	9	8	8	7
R-squared	0.57	0.58	0.59	0.62	0.77	0.78	0.75

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 9: Growth equation's results 1985-1999 - major exporters of cork and wood

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.048	-0.048	-0.049	-0.048	-0.005	-0.005	-0.003
	*0.052**	*0.054**	*0.052**	*0.054**	*0.748*	*0.745*	*0.843*
Openness to trade with EU	0.028	0.019	0.026	0.016	0.042	0.038	0.023
	0.255	*0.445*	*0.293*	*0.514*	*0.287*	*0.338*	*0.605*
Openness to trade with the rest of the world	0.032	0.036	0.032	0.036	0.030	0.030	0.024
	*0.018*****	*0.014*****	*0.018*****	*0.017*****	*0.053**	*0.059**	*0.170*
Openness to trade with China	0.011	0.013	0.011	0.012	0.013	0.012	0.011
	0.157	*0.121*	*0.149*	*0.126*	*0.119*	*0.127*	*0.188*
School enrollment, secondary	-0.057	-0.107	-0.079	-0.105	-0.094	-0.094	-0.195
(%)	*0.630*	*0.558*	*0.517*	*0.560*	*0.556*	*0.557*	*0.297*
Population	-1.498	-2.362	-1.442	-2.533	-2.915	-2.972	-3.671
	*0.011*****	*0.199*	*0.016*****	*0.158*	*0.074**	*0.067**	*0.058**
Gross domestic savings	0.002	0.006	0.002	0.007	-0.001	-0.001	-0.005
(GDP ratio)	*0.842*	*0.552*	*0.843*	*0.518*	*0.859*	*0.902*	*0.534*
Inflation		-0.006		-0.008	-0.005	-0.006	-0.006
		0.583		*0.510*	*0.579*	*0.560*	*0.581*
Life expectancy at birth, total			-0.929	-2.111		-1.089	-0.456
(years)			*0.429*	*0.251*		*0.502*	*0.789*
External debt					-0.089	-0.083	-0.087
(GNI ratio)					*0.059**	*0.080**	*0.081**
Domestic credit provided by banking sector							-0.017
(GDP ratio)							*0.326*
Constant	0.013	0.055	0.011	0.056	0.054	0.053	0.079
	0.602	*0.291*	*0.649*	*0.272*	*0.231*	*0.241*	*0.137*
Observations	116	101	116	101	96	96	93
Number of countries	11	10	11	10	9	9	9
R-squared	0.69	0.72	0.69	0.72	0.57	0.57	0.58

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 10: Growth equation's results 2000-2012 - major exporters of cork and wood

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.015	0.022	0.018	0.022	0.022	0.023	0.007
	0.464	*0.372*	*0.419*	*0.380*	*0.074**	*0.080**	*0.417*
Openness to trade with EU	-0.020	-0.023	-0.021	-0.023	0.105	0.109	0.070
	0.706	*0.659*	*0.699*	*0.673*	*0.006****	*0.008****	*0.002****
Openness to trade with the rest of the world	0.017	0.016	0.017	0.016	0.014	0.014	0.010
	0.232	*0.252*	*0.240*	*0.268*	*0.075**	*0.070**	*0.180*
Openness to trade with China	0.026	0.016	0.028	0.016	-0.029	-0.029	-0.027
	0.355	*0.594*	*0.336*	*0.587*	*0.178*	*0.193*	*0.029***
School enrollment, secondary	-0.014	-0.009	-0.015	-0.011	-0.039	-0.043	-0.035
(%)	*0.865*	*0.919*	*0.862*	*0.905*	*0.537*	*0.458*	*0.385*
Population	2.315	-1.717	2.073	-2.753	-6.820	-7.972	-1.515
	0.606	*0.791*	*0.647*	*0.705*	*0.049***	*0.070**	*0.606*
Gross domestic savings	0.016	0.013	0.015	0.013	0.019	0.019	0.013
(GDP ratio)	*0.091**	*0.167*	*0.114*	*0.179*	*0.043***	*0.050***	*0.021***
Inflation		-0.014		-0.015	-0.079	-0.076	-0.017
		0.714		*0.689*	*0.000****	*0.000****	*0.799*
Life expectancy at birth, total			-0.127	-0.661		-1.143	0.144
(years)			*0.897*	*0.524*		*0.384*	*0.900*
External debt					0.029	0.029	0.027
(GNI ratio)					*0.373*	*0.361*	*0.166*
Domestic credit provided by banking sector							-0.005
(GDP ratio)							*0.369*
Constant	-0.047	0.063	-0.018	0.091	0.266	0.299	0.050
	0.680	*0.693*	*0.871*	*0.619*	*0.021***	*0.033***	*0.486*
Observations	96	90	93	88	67	67	61
Number of countries	11	11	11	11	10	10	10
R-squared	0.48	0.51	0.49	0.51	0.63	0.63	0.91

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

The estimations' results of the first sub-period indicate that these three groups of countries clearly benefit from openness to trade with the rest of the world whereas their trade relations with the USA are detrimental to them. Trade with the EU and with China have no significant impact on growth in any of the groups. According to the results of the second sub-period, trade with China is favorable for the African economies that are major exporters of petroleum but it has no impact on economic growth of the other groups of countries. This suggests that, during the last decade, China has contributed to economic growth in Africa, to the greatest extent, through its imports of petroleum from Africa. The estimation results also show that openness to trade with the USA and with the rest of the world both have a positive impact on the GDP of major exporters of wood. However, the coefficients of these variables are statistically significant in only two specifications and only at the 10% level. The economic growth of this group is found to be mainly and positively influenced by trade with the EU. For the countries that are major exporters of metalliferous ores and metal scrap, the effects of trade relations with the EU and with the rest of the world are relatively important. The coefficients of these variables have a positive sign and are significantly different from zero in three specifications (at the 1% and 5% level). On the whole, the results suggest that trade positively affects growth in African countries through, mainly, their exports of petroleum to China, their exports of wood to the EU and their exports of metalliferous ores and metal scrap to the EU and to the rest of the world.

Regarding the right-hand-side variables that are not related to trade, the results tend to be close to the ones of the basic set of specifications, with some exceptions.

Table 11: Growth equation's results 1985-1999 - countries with higher real GDP per capita

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.059	-0.077	-0.057	-0.075	-0.050	-0.046	-0.076
	*0.011***	*0.000****	*0.018***	*0.001****	*0.043***	*0.081**	*0.011***
Openness to trade with EU	-0.078	-0.066	-0.076	-0.058	-0.072	-0.063	-0.097
	*0.006****	*0.052**	*0.010****	*0.084**	*0.027***	*0.042***	*0.081**
Openness to trade with the rest of the world	0.014	0.017	0.015	0.020	0.058	0.059	0.062
	0.710	*0.630*	*0.688*	*0.569*	*0.024***	*0.024***	*0.039***
Openness to trade with China	0.002	0.013	0.002	0.013	0.010	0.011	0.002
	0.843	*0.220*	*0.851*	*0.207*	*0.316*	*0.301*	*0.914*
School enrollment, secondary	0.072	0.197	0.059	0.177	0.117	0.096	0.623
(%)	*0.607*	*0.311*	*0.685*	*0.376*	*0.483*	*0.572*	*0.174*
Population	0.972	0.050	1.109	0.298	-0.050	0.068	0.660
	0.709	*0.984*	*0.665*	*0.905*	*0.985*	*0.979*	*0.776*
Gross domestic savings	0.088	0.128	0.088	0.132	0.108	0.109	0.102
(GDP ratio)	*0.004****	*0.001****	*0.005****	*0.001****	*0.013***	*0.014***	*0.164*
Inflation		0.079		0.079	0.062	0.060	0.094
		0.335		*0.339*	*0.519*	*0.533*	*0.524*
Life expectancy at birth, total			0.530	1.260		1.307	1.975
(years)			*0.643*	*0.217*		*0.168*	*0.055**
External debt					-0.113	-0.111	-0.066
(GNI ratio)					*0.024***	*0.024***	*0.215*
Domestic credit provided by banking sector							-0.060
(GDP ratio)							*0.540*
Constant	0.022	-0.010	0.015	-0.025	0.005	-0.004	-0.066
	0.773	*0.893*	*0.837*	*0.752*	*0.944*	*0.953*	*0.416*
Observations	87	80	87	80	75	75	61
Number of countries	8	7	8	7	6	6	5
R-squared	0.75	0.79	0.75	0.80	0.64	0.65	0.66

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 12: Growth equation's results 2000-2012 - countries with higher real GDP per capita

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.017 *0.467*	-0.002 *0.939*	0.017 *0.470*	-0.002 *0.914*	0.011 *0.345*	0.011 *0.360*	0.031 *0.114*
Openness to trade with EU	-0.084 *0.037***	-0.064 *0.047***	-0.083 *0.041***	-0.065 *0.047***	0.002 *0.847*	0.002 *0.866*	-0.020 *0.545*
Openness to trade with the rest of the world	0.014 *0.650*	0.027 *0.381*	0.014 *0.648*	0.028 *0.363*	-0.006 *0.509*	-0.006 *0.545*	-0.006 *0.586*
Openness to trade with China	-0.022 *0.443*	-0.009 *0.779*	-0.022 *0.442*	-0.005 *0.894*	-0.014 *0.267*	-0.013 *0.310*	0.013 *0.600*
School enrollment, secondary ***(%)***	-0.436 *0.300*	-0.469 *0.213*	-0.436 *0.302*	-0.462 *0.205*	0.031 *0.767*	0.032 *0.761*	0.021 *0.906*
Population	1.419 *0.749*	1.020 *0.828*	1.806 *0.697*	-0.907 *0.859*	-0.676 *0.727*	-1.151 *0.640*	-5.723 *0.017***
Gross domestic savings ***(GDP ratio)***	0.081 *0.008****	0.085 *0.008****	0.081 *0.007****	0.090 *0.010****	0.072 *0.176*	0.075 *0.162*	0.134 *0.018***
Inflation		0.962 *0.103*		1.017 *0.097**	-0.089 *0.663*	-0.077 *0.709*	-0.274 *0.282*
Life expectancy at birth, total ***(years)***			0.200 *0.813*	-1.039 *0.432*		-0.212 *0.756*	-0.970 *0.121*
External debt ***(GNI ratio)***					0.021 *0.294*	0.021 *0.304*	0.011 *0.605*
Domestic credit provided by banking sector ***(GDP ratio)***							-0.013 *0.241*
Constant	0.001 *0.989*	-0.032 *0.693*	0.006 *0.947*	-0.001 *0.994*	0.029 *0.343*	0.035 *0.339*	0.101 *0.005****
Observations	75	73	74	72	59	58	45
Number of countries	8	8	8	8	6	6	5
R-squared	0.64	0.67	0.64	0.68	0.54	0.55	0.71

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

The estimations for the group of the countries with higher real GDP per capita lead to interesting results that are very different from those of the basic set of specifications. They indicate that, during the first sub-period, growth of these economies was positively influenced by trade with the rest of the world and by domestic investment. On the other side, openness to trade with the USA and with the EU both had a negative impact on GDP and openness to trade with China was not significant. Regarding the results of the second sub-period, the results suggest that the only source of economic growth is domestic investment. It can also be mentioned that openness to trade with the EU has a negative impact on GDP. On the whole, these results show that, in the richest African economies, growth depends mainly on domestic investment.

4.2 Robustness tests

To check that the results are robust, a variety of additional specifications are performed. First, the same specifications have been estimated with initial GDP as additional right-hand side variables. According to economic growth theory, the sign of the coefficients of initial GDP must be negative as it represents conditional convergence. The results of these additional estimations show that this coefficient is, as expected, negative and statistically significant. Regarding the other explanatory variables, these additional results lead to the same conclusions as the basic set of specifications. Again, the second sub-period's estimations confirm the loss of importance of trade with the EU for African economic growth during the last decade and the suspicion that it has been substituted by trade with China.

Table 13: Growth equation's results 1985-1999 - specifications with initial GDP

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.019	-0.020	-0.019	-0.020	-0.003	-0.003	-0.004
	*0.045***	*0.046***	*0.045***	*0.046***	*0.566*	*0.554*	*0.456*
Openness to trade with EU	0.022	0.020	0.023	0.021	0.052	0.053	0.042
	0.186	*0.211*	*0.174*	*0.195*	*0.011***	*0.011***	*0.029***
Openness to trade with the rest of the world	0.011	0.013	0.011	0.012	0.021	0.021	0.016
	0.157	*0.140*	*0.161*	*0.142*	*0.012***	*0.012***	*0.034***
Openness to trade with China	0.000	0.000	0.000	0.000	0.003	0.003	0.004
	0.962	*0.949*	*0.961*	*0.942*	*0.511*	*0.502*	*0.291*
Initial GDP per capita	-0.032	-0.029	-0.031	-0.029	-0.024	-0.024	0.000
	*0.022***	*0.093**	*0.023***	*0.089**	*0.139*	*0.135*	*0.978*
School enrollment, secondary	0.011	0.046	0.014	0.048	0.044	0.046	0.017
(%)	*0.795*	*0.374*	*0.748*	*0.348*	*0.358*	*0.337*	*0.734*
Population	-0.881	-0.735	-0.871	-0.716	-0.741	-0.726	-0.746
	*0.007****	*0.041***	*0.010***	*0.056**	*0.025***	*0.035***	*0.028***
Gross domestic savings	0.000	0.002	0.001	0.002	0.001	0.001	0.001
(GDP ratio)	*0.903*	*0.626*	*0.863*	*0.592*	*0.732*	*0.699*	*0.798*
Inflation		-0.026		-0.026	-0.024	-0.024	-0.022
		*0.048***		*0.050***	*0.027***	*0.028***	*0.014***
Life expectancy at birth, total			0.211	0.233		0.193	-0.061
(years)			*0.486*	*0.437*		*0.485*	*0.820*
External debt					-0.078	-0.078	-0.073
(GNI ratio)					*0.000****	*0.000****	*0.000****
Domestic credit provided by banking sector							-0.008
(GDP ratio)							*0.286*
Constant	0.230	0.218	0.225	0.216	0.222	0.220	0.040
	*0.008****	*0.036***	*0.009****	*0.037***	*0.029***	*0.031***	*0.615*
Observations	371	340	371	340	333	333	306
Number of countries	35	33	35	33	32	32	31
R-squared	0.50	0.53	0.50	0.53	0.46	0.46	0.44

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 14: Growth equation's results 2000-2012 - specifications with initial GDP

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.001 *0.858*	0.004 *0.678*	0.002 *0.806*	0.003 *0.713*	0.002 *0.844*	0.002 *0.843*	-0.001 *0.871*
Openness to trade with EU	-0.006 *0.762*	-0.004 *0.856*	-0.007 *0.747*	-0.004 *0.856*	0.036 *0.077**	0.036 *0.075**	0.028 *0.146*
Openness to trade with the rest of the world	0.022 *0.028***	0.023 *0.028***	0.021 *0.029***	0.023 *0.028***	0.023 *0.020***	0.023 *0.020***	0.028 *0.031***
Openness to trade with China	0.026 *0.035***	0.026 *0.030***	0.026 *0.033***	0.028 *0.022***	0.030 *0.022***	0.030 *0.024***	0.027 *0.056**
Initial GDP per capita	-0.038 *0.011***	-0.042 *0.014***	-0.040 *0.012***	-0.046 *0.008****	-0.082 *0.000****	-0.080 *0.000****	-0.050 *0.060**
School enrollment, secondary ***(%)***	-0.070 *0.231*	-0.064 *0.300*	-0.070 *0.251*	-0.061 *0.338*	-0.001 *0.986*	-0.001 *0.992*	-0.037 *0.466*
Population	1.463 *0.351*	1.221 *0.521*	1.361 *0.389*	0.978 *0.599*	-1.823 *0.261*	-1.784 *0.270*	-0.389 *0.750*
Gross domestic savings ***(GDP ratio)***	0.018 *0.001****	0.017 *0.001****	0.018 *0.001****	0.018 *0.001****	0.023 *0.000****	0.024 *0.000****	0.023 *0.000****
Inflation		-0.011 *0.630*		-0.008 *0.725*	-0.072 *0.002****	-0.074 *0.002****	-0.079 *0.270*
Life expectancy at birth, total ***(years)***			-0.347 *0.581*	-0.896 *0.148*		0.253 *0.724*	0.948 *0.199*
External debt ***(GNI ratio)***					-0.031 *0.054**	-0.032 *0.054**	-0.039 *0.017***
Domestic credit provided by banking sector ***(GDP ratio)***							0.001 *0.925*
Constant	0.328 *0.050***	0.367 *0.061**	0.332 *0.060**	0.399 *0.045***	0.788 *0.000****	0.773 *0.000****	0.505 *0.064**
Observations	272	264	265	258	187	187	165
Number of countries	34	34	34	34	32	32	30
R-squared	0.45	0.46	0.45	0.46	0.56	0.56	0.69

All variables except dummies are expressed in log and are first-differenced
Robust p values in italics
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

A second robustness test consists of the introduction in the specifications of several dummy variables in order to take into account whether or not the country is at war (war), is a WTO member (WTO), has a democratic political system (democracy) or is an oil producer (oil). These specifications (see Tables 15 and 16) for the two different sub-samples do not change the conclusions given by the specifications without dummy variables. Nevertheless, it must be noted that in the second sub-sample, the dummy for WTO membership is dropped due to collinearity. According to the second sub-period's results, openness to trade with the EU has a significant impact on GDP in two specifications and at the 10% level. This confirms again that the impact of trade with the EU on African economic growth became weaker during the final decade of the period under consideration.

Regarding the coefficients of the dummies, none of them is significantly different from zero except that of oil during the second sub-period but only in two specifications and at the 10% level. The fact that WTO appears to have no influence on GDP growth suggests that African economies are not sufficiently competitive to be able to take advantage of new or wider market access resulting from joining this organization. The results also imply that war has no influence on economic growth in Africa. This result may be explained by the fact that war is endogenous to GDP growth as suggested by the economics of civil war literature[10]. The results also suggest that democracy is not a determinant of growth in Africa, which could be explained by the fact that this political system is not yet developed in Africa to the point that it has a positive impact on economic growth (through, for instance, the stabilization of the political system). Another result is that whether or not a country produces oil hardly influences its GDP growth; this and the fact that the coefficient of oil is negative might be explained by the fact that oil revenues may generate corruption, rent seeking activities or social conflicts.

Table 15: Growth equation's results 1985-1999 - specifications with dummies

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	-0.019	-0.019	-0.019	-0.020	-0.003	-0.003	-0.004
	*0.041***	*0.039***	*0.037***	*0.035***	*0.585*	*0.539*	*0.458*
Openness to trade with EU	0.021	0.018	0.020	0.017	0.051	0.050	0.041
	0.226	*0.276*	*0.234*	*0.290*	*0.016***	*0.017***	*0.039***
Openness to trade with the rest of the world	0.011	0.012	0.012	0.013	0.021	0.021	0.017
	0.170	*0.164*	*0.146*	*0.142*	*0.014***	*0.011***	*0.026***
Openness to trade with China	0.000	0.001	0.000	0.001	0.002	0.002	0.003
	0.971	*0.855*	*0.962*	*0.842*	*0.522*	*0.521*	*0.333*
School enrollment, secondary	0.000	0.040	-0.002	0.041	0.043	0.044	0.021
(%)	*0.993*	*0.434*	*0.968*	*0.431*	*0.370*	*0.367*	*0.680*
Population	-0.864	-0.743	-0.750	-0.627	-0.719	-0.623	-0.574
	*0.019***	*0.044***	*0.009****	*0.020***	*0.034***	*0.017***	*0.028***
Gross domestic savings	0.000	0.002	0.000	0.001	0.001	0.001	0.000
(GDP ratio)	*0.893*	*0.619*	*0.999*	*0.724*	*0.712*	*0.810*	*0.972*
Inflation		-0.029		-0.029	-0.025	-0.025	-0.021
		*0.043***		*0.046***	*0.035***	*0.038***	*0.020***
Life expectancy at birth, total			-0.136	-0.137		-0.115	-0.155
(years)			*0.145*	*0.163*		*0.249*	*0.171*
External debt					-0.077	-0.077	-0.073
(GNI ratio)					*0.000****	*0.000****	*0.000****
Domestic credit provided by banking sector							-0.008
(GDP ratio)							*0.299*
WTO	-0.007	-0.006	-0.008	-0.008	0.000	-0.001	0.000
	0.623	*0.668*	*0.544*	*0.583*	*0.972*	*0.943*	*0.973*
Oil	-0.004	0.014	-0.005	0.013	-0.010	-0.011	-0.015
	0.881	*0.548*	*0.852*	*0.580*	*0.539*	*0.528*	*0.369*
Democracy	0.012	0.010	0.011	0.010	0.012	0.011	0.009
	0.309	*0.424*	*0.333*	*0.447*	*0.296*	*0.310*	*0.465*
War	-0.005	-0.007	-0.005	-0.007	-0.006	-0.007	-0.008
	0.513	*0.391*	*0.479*	*0.357*	*0.377*	*0.341*	*0.279*
Constant	0.032	0.028	0.029	0.025	0.038	0.035	-0.004
	*0.046***	*0.068**	*0.044***	*0.058**	*0.004****	*0.002****	*0.783*
Observations	371	340	371	340	333	333	306
Number of countries	35	33	35	33	32	32	31
R-squared	0.50	0.53	0.50	0.53	0.46	0.46	0.45

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

[10] According to Gyimah-Brempong and Corley (2012), only few studies include war as an explanatory variable and the results do not lead to clear-cut conclusions.

Table 16: Growth equation's results 2000-2012 - specifications with dummies

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.000	0.002	0.001	0.002	-0.001	-0.002	-0.005
	0.993	*0.802*	*0.922*	*0.804*	*0.934*	*0.832*	*0.512*
Openness to trade with EU	-0.004	-0.003	-0.003	-0.002	0.034	0.037	0.033
	0.829	*0.878*	*0.873*	*0.935*	*0.088**	*0.075**	*0.089**
Openness to trade with the rest of the world	0.020	0.022	0.020	0.022	0.024	0.023	0.025
	*0.036***	*0.038***	*0.039***	*0.042***	*0.020***	*0.023***	*0.045***
Openness to trade with China	0.025	0.026	0.025	0.026	0.029	0.029	0.026
	*0.021***	*0.019***	*0.020***	*0.019***	*0.011***	*0.010****	*0.035***
School enrollment, secondary	-0.064	-0.058	-0.065	-0.060	0.003	0.002	-0.044
(%)	*0.299*	*0.373*	*0.313*	*0.381*	*0.963*	*0.969*	*0.389*
Population	-0.035	-0.323	0.122	-0.198	-1.325	-1.218	0.118
	0.981	*0.850*	*0.934*	*0.909*	*0.389*	*0.446*	*0.930*
Gross domestic savings	0.017	0.017	0.017	0.017	0.024	0.024	0.023
(GDP ratio)	*0.001****	*0.002****	*0.002****	*0.002****	*0.000****	*0.000****	*0.000****
Inflation		-0.013		-0.013	-0.071	-0.070	-0.078
		0.566		*0.582*	*0.003****	*0.004****	*0.261*
Life expectancy at birth, total			-0.161	-0.132		-0.231	-0.171
(years)			*0.514*	*0.648*		*0.468*	*0.512*
External debt					-0.026	-0.031	-0.036
(GNI ratio)					*0.111*	*0.071**	*0.022***
Domestic credit provided by banking sector							0.000
(GDP ratio)							*0.967*
WTO	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
Oil	-0.041	-0.037	-0.041	-0.038	-0.033	-0.034	-0.030
	*0.076**	*0.104*	*0.078**	*0.100*	*0.201*	*0.194*	*0.246*
Democracy	0.003	0.007	0.002	0.006	-0.004	-0.007	-0.010
	0.820	*0.622*	*0.875*	*0.666*	*0.814*	*0.688*	*0.551*
War	-0.004	0.000	-0.006	-0.001	0.004	0.003	-0.001
	0.621	*0.985*	*0.461*	*0.896*	*0.683*	*0.790*	*0.875*
Constant	0.018	0.047	0.020	0.022	0.023	0.262	0.051
	0.635	*0.314*	*0.619*	*0.616*	*0.672*	*0.000****	*0.124*
Observations	272	264	263	256	187	185	163
Number of countries	34	34	34	34	32	32	30
R-squared	0.45	0.46	0.45	0.47	0.56	0.57	0.70

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

As previously mentioned, annual data are used because temporal aggregation presents the disadvantage of generating a loss of dynamic information. However, despite this, averaging data over several years allows a reduction of volatility, from which yearly time series may suffer, and that could have an impact on the estimations' results. Thus, a third robustness test is therefore performed with data that are averaged over 4 years (for each series, the arithmetic mean of the following years is calculated: 1985-1988, 1989-1992, etc; this process results in 7 years) in order to smooth the fluctuations in the individual series. The same specifications are estimated (see tables 17 and 18). According to these estimations' results, most of the coefficients of the explanatory variables are not statistically significant. This might be a consequence of the process of averaging data, which, as mentioned before, might generate a loss of information contained in the series. However, these results also suggest that, since the last decade, trade with China has been favorable for growth in Africa and seems to have become more important to it than trade with the EU.

Table 17: Growth equation's results 1985-1999 - specifications with averaged yearly data

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.016	0.066	0.026	0.066	0.054	0.055	0.111
	0.711	*0.251*	*0.509*	*0.264*	*0.337*	*0.343*	*0.046***
Openness to trade with EU	0.051	0.021	0.066	0.032	0.044	0.056	0.065
	0.186	*0.701*	*0.040***	*0.480*	*0.369*	*0.210*	*0.182*
Openness to trade with the rest of the world	0.064	0.057	0.067	0.063	0.073	0.079	0.056
	*0.053**	*0.112*	*0.031***	*0.093**	*0.041***	*0.047***	*0.169*
Openness to trade with China	-0.010	-0.012	-0.011	-0.012	-0.010	-0.010	-0.016
	0.328	*0.325*	*0.300*	*0.330*	*0.386*	*0.384*	*0.143*
School enrollment, secondary	0.025	0.018	0.019	0.012	0.035	0.028	0.014
(%)	*0.666*	*0.772*	*0.719*	*0.845*	*0.627*	*0.686*	*0.874*
Population	-0.302	0.608	-0.779	0.164	0.612	0.112	-0.869
	0.589	*0.586*	*0.221*	*0.889*	*0.558*	*0.917*	*0.473*
Gross domestic savings	-0.001	-0.002	-0.003	-0.002	-0.002	-0.003	-0.004
(GDP ratio)	*0.963*	*0.853*	*0.796*	*0.825*	*0.817*	*0.781*	*0.623*
Inflation		-0.021		-0.017	-0.018	-0.014	-0.051
		*0.090**		*0.255*	*0.129*	*0.337*	*0.005****
Life expectancy at birth, total			0.863	0.316		0.348	0.410
(years)			*0.188*	*0.709*		*0.677*	*0.634*
External debt					-0.084	-0.084	-0.054
(GNI ratio)					*0.059**	*0.064**	*0.210*
Domestic credit provided by banking sector							-0.057
(GDP ratio)							*0.095**
Constant	0.025	-0.110	0.082	-0.063	-0.014	0.037	0.113
	0.696	*0.350*	*0.285*	*0.613*	*0.897*	*0.734*	*0.394*
Observations	77	70	77	70	68	68	60
Number of countries	31	28	31	28	27	27	26
R-squared	0.85	0.87	0.86	0.88	0.89	0.89	0.93

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Table 18: Growth equation's results 2000-2012 - specifications with averaged yearly data

Dependant variable: first difference of real per capita GDP in PPP

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Openness to trade with USA	0.002	0.006	-0.037	-0.054	-0.052	-0.052	-0.063
	0.931	*0.839*	*0.283*	*0.089**	*0.112*	*0.123*	*0.007****
Openness to trade with EU	-0.015	0.010	0.001	0.025	0.029	0.029	0.336
	0.712	*0.783*	*0.972*	*0.294*	*0.327*	*0.348*	*0.059**
Openness to trade with the rest of the world	-0.058	-0.011	-0.112	-0.056	-0.064	-0.063	-0.403
	0.121	*0.891*	*0.095**	*0.584*	*0.473*	*0.532*	*0.050**
Openness to trade with China	0.087	0.048	0.127	0.035	0.035	0.034	0.238
	*0.001****	*0.502*	*0.002****	*0.544*	*0.527*	*0.573*	*0.027***
School enrollment, secondary	-0.168	-0.105	-0.208	-0.087	-0.106	-0.105	-0.573
(%)	*0.284*	*0.550*	*0.461*	*0.710*	*0.597*	*0.618*	*0.043***
Population	3.115	2.528	0.220	-1.728	-1.105	-1.062	1.631
	*0.081**	*0.284*	*0.892*	*0.292*	*0.406*	*0.589*	*0.240*
Gross domestic savings	0.048	0.045	0.042	0.002	0.000	0.000	-0.040
(GDP ratio)	*0.019***	*0.073**	*0.175*	*0.966*	*1.000*	*0.998*	*0.185*
Inflation		-0.047		-0.103	-0.096	-0.096	-0.056
		0.454		*0.037***	*0.037***	*0.050***	*0.178*
Life expectancy at birth, total			-0.109	-0.015		0.031	0.120
(years)			*0.884*	*0.985*		*0.969*	*0.839*
External debt					0.027	0.027	0.471
(GNI ratio)					*0.562*	*0.583*	*0.048***
Domestic credit provided by banking sector							-0.386
(GDP ratio)							*0.041***
Constant	-0.272	-0.181	0.079	0.335	0.292	0.287	0.245
	*0.094**	*0.504*	*0.625*	*0.108*	*0.066**	*0.206*	*0.054**
Observations	61	55	54	49	48	48	40
Number of countries	31	28	31	28	27	27	24
R-squared	0.91	0.92	0.94	0.96	0.95	0.95	0.99

All variables except dummies are expressed in log and are first-differenced

Robust p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

On the whole, with some exceptions, the robustness tests tend to lead to the same conclusions resulting from the basic set of specifications, and confirm the two main results of this study. First, openness to trade with China had a positive impact on GDP growth in Africa only during the final decade of the period under consideration, a period during which the dynamics of trade between China and Africa became much stronger. Second, openness to trade with the EU tended to lose its influence on GDP growth in Africa during the second sub-period. This suggests that a substitution effect between the impact of openness to trade with the EU and the one of openness to trade with China may have taken place in Africa during the final ten years of the period under consideration.

5. Summary

In this study, the global impact of trade between Africa and China on African GDP growth has been analyzed using a panel data econometric model for 37 countries over the period from 1985 to 2012 and for two different sub-periods. Control variables used in most economic growth studies have been taken into account and several robustness tests have been performed.

Regarding the non-trade growth control variables, as expected, domestic savings has a positive impact on GDP, while inflation, population growth and external debt are detrimental to economic growth. Secondary school enrollment, life expectancy and domestic credit provided by the banking sector have no statistically significant impact on GDP in Africa in the selected sample. The fact that, in Africa, economic growth comes mainly from the increasing development of the exploitation of natural resources, which is capital and not labor intensive, might explain why secondary school enrollment and life expectancy at birth are non-significant. In a similar vein, under-development of the financial sector might explain why domestic credit providing by the banking sector is not statistically significant.

The openness to trade variables provide interesting insights. First, total openness to trade has a positive influence on African growth. Second, disaggregating across trading partners reveals that for Africa, trade with the EU as well as with the rest of the world is beneficial to the economy. Trade links with the USA appear to have a negative impact on GDP growth during the first sub-period while it has no influence on it during the last decade. Regarding openness to trade with China, it has a positive global influence on economic growth but only during the final decade of the period under consideration. Moreover, during the same period, openness to trade with China has more influence on African economic growth than does openness to trade with the EU. This suggests that the recent surge in trade flows between Africa and China may have important long-term consequences for the African continent.

However, it is important to remember that the long-term effects of trade also depend on domestic policies. African economies remain dependent on price-volatile goods and their economic links with China tend to be identical to their relations with the EU. Thus, in order to avoid instabilities experienced in the past, Africa will have to make appropriate reforms at the social, economic and political levels aiming at encouraging long-term economic growth. In particular, African countries need to diversify their economic structures and improve their ability to implement new technologies (e.g. Elu and Price (2010)). Another important domain is the stabilization of macroeconomic conditions, which would allow an increase in domestic or foreign investment.

Several extensions of the present analysis could be considered although they depend on data availability. As suggested by the results of the estimations performed for different groups of countries, disaggregating the analyses by country and/or by sector would lead to a better understanding of the trade links between Africa and China. Using panel data models with heterogeneous coefficients could greatly improve the precision of the results. Another interesting extension would be to analyze which types of substitution effects may be concealed behind the differences of impact between China and the EU on recent African growth performance.

Appendix A: Data summary and definitions

Selected African countries are the following: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo (Republic of), Congo (Democratic Republic of), Côte d'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Equatorial Guinea, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Togo, Tunisia, Uganda and Zambia.

Table A.1: Data summary

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
GDP per capita real PPP 2005	1035	2678.3	3872.7	100.9	30988.2
Gross domestic savings (% GDP)	920	14.3	17.4	-48.5	94.9
Life expectancy at birth, total (years)	998	53.2	7.5	23.8	74.8
Scholl enrollment, secondary (% gross)	955	28.6	20.4	3.3	117.8
External debt stocks (% GNI)	798	112.6	98.9	3.4	765.8
Population (total)	1036	16700000	23000000	312772	169000000
Inflation (consumer price index, 2005=100)	961	81.4	96.6	0.0	2378.4
Domestic credit provided by the banking sector (%	952	35	83	-73	1255
Openness to trade Total	978	69	33	11	275
Openness to trade with USA	1036	7	10	0	70
Openness to trade with EU	1036	34	89	1	1843
Openness to trade with the rest of the world	978	31	50	-718	149
Openness to trade with China	1036	6.218579	20.56359	0	344.41

Data definitions

Democracy

A country is considered as democratic when it is classified as an electoral democracy by Freedom House. According to the latter, for a country to be qualified as an electoral democracy, it must have satisfied the following criteria: 1. A competitive, multiparty political system; 2. Universal adult suffrage for all citizens (with exceptions for restrictions that states may legitimately place on citizens as sanctions for criminal offenses); 3. Regularly contested elections conducted in conditions of ballot secrecy, reasonable ballot security, and in the absence of massive voter fraud, and that yield results that are representative of the public will; 4. Significant public access of major political parties to the electorate through the media and through generally open political campaigning. Source: www.freedomhouse.org.

Domestic credit provided by banking sector (% GDP)

Domestic credit provided by the banking sector includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net. The banking sector includes monetary authorities and deposit money banks, as well as other banking institutions where data are available (including institutions that do not accept transferable deposits but do incur such liabilities as time and savings deposits). Examples of other banking institutions are savings and mortgage loan institutions and building and loan associations. Sources: International Monetary Fund, International Financial Statistics and data files, and World Bank and OECD GDP estimates.

Exports of goods and services (current US$)

Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

External debt stocks (% of GNI)

Total external debt stocks to gross national income. Total external debt is debt owed to nonresidents repayable in foreign currency, goods, or services. Total external debt is the sum of public, publicly guaranteed, and private nonguaranteed long-term debt, use of International Monetary Fund (IMF) credit, and short-term debt. Short-term debt includes all debt having an original maturity of one year or less and interest in arrears on long-term debt. GNI (formerly gross national product (GNP)) is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. Source: World Bank, Global Development Finance.

GDP, Purchasing Power Parity (PPP) (constant 2005 international $)

PPP GDP is gross domestic product converted to international (US) dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2000 international dollars. Source: World Bank, International Comparison Program database.

Gross domestic savings (% GDP)

Gross domestic savings are calculated as GDP less final consumption expenditure (total consumption). Sources: World Bank national accounts data, and OECD National Accounts data files.

Imports of goods and services (current US$)

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

Inflation, consumer prices (annual %)

Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used. Source: International Monetary Fund, International Financial Statistics and data files.

Life expectancy at birth, total (years)

Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. Sources: Derived from male and female life expectancy at birth from sources such as: (1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Reprot (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

Population (total)

Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates. Sources: (1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

School enrollment, secondary (% gross)

Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers. Sources: UNESCO Institute for Statistics.

Trade structure by partner, product or service-category

Imports and exports of various type of merchandises of African countries with selected partners (China, the EU and the USA)

Merchandise trade by trading partner and are expressed in thousands of United States dollars. The data are also summarized by group of economies, for both reporting economy and trading partner, and by broader product groups. Sources: (1) United Nations (UN) Department of Economic and Social Affairs (DESA) Statistics Division, UN International Trade Statistics (COMTRADE); (2) IMF, Direction of Trade Statistics; (3) Eurostat, Statistics database; (4) UNCTAD, UNCTADstat, Total Merchandise Trade; (5) UNCTAD secretariat calculations.

War

Data on wars come from the Correlates of War (COW) Project and include different kind of conflicts described below:

Non-state wars: Wars between or among non-state entities. Such entities include governments of other types of geopolitical units (GPUs), such as dependencies or non-state autonomous entities that do not meet the criteria of system membership. They also might involve nonterritorial entities (NTEs) or non-state armed groups (NSAs) that have no defined territorial base.

Intra-state wars: Wars that predominantly take place within the recognized territory of a state, or intra-state wars.

Inter-state wars: Wars that take place between or among the recognized states, or inter-state wars.

Extra-state wars: Wars in the middle category - wars that take place between a state(s) and a nonstate entity outside the borders of the state, or extra-state wars.

Source: Correlates of War (COW) Project (http://www.correlatesofwar.org/)

Appendix B: Contribution of GDP components to GDP growth

The 22 African countries for which the contribution of GDP components to GDP growth is calculated are those for which national accounts data are available, i.e. : Algeria, Botswana, Central African Republic, Congo Dem. Rep., Congo Rep., Cote d'Ivoire, Ethiopia, Gabon, Ghana, Guinea, Kenya, Madagascar, Malawi, Morocco, Mozambique, Namibia, Rwanda, Senegal, South Africa, Tunisia, Uganda and Zambia.

Table B.1: Contribution of GDP components to GDP growth

Country	Averaged contribution (in %) to nominal GDP growth of											Growth rate (in %) of nominal GDP
	Household final consumption expenditure	*General government final consumption expenditure*	**Final consumption expenditure**	**Gross capital formation**	*EU*	*USA*	*China*	*Rest of the world*	***Total net exports of goods***	***Total net exports of services***	**Total net exports of goods and services**	
Algeria	*1.22*	*0.93*	2.15	1.93	*0.56*	*0.50*	*-0.11*	*0.35*	*1.30*	*0.30*	1.60	**5.69**
Botswana	*4.31*	*2.36*	6.67	3.39	*-0.03*	*1.29*	*-0.04*	*0.14*	*1.36*	*-0.63*	0.73	**10.79**
Central African Rep.	*4.10*	*0.18*	4.28	0.49	*-0.03*	*-0.27*	*0.06*	*-0.28*	*-0.52*	*0.07*	-0.45	**4.32**
Congo Dem. Rep.	*3.19*	*0.95*	4.14	1.46	*-0.15*	*-0.43*	*0.89*	*-0.63*	*-0.33*	*-0.66*	-0.99	**4.61**
Congo Rep.	*1.98*	*0.78*	2.75	1.71	*1.18*	*0.34*	*3.24*	*2.32*	*7.09*	*-2.17*	4.92	**9.39**
Côte d'Ivoire	*4.98*	*0.45*	5.43	0.56	*0.06*	*0.26*	*-0.13*	*0.30*	*0.49*	*-0.29*	0.21	**6.20**
Ethiopia	*5.00*	*0.66*	5.66	2.77	*-0.15*	*-0.06*	*-0.30*	*-0.62*	*-1.13*	*-0.60*	-1.74	**6.69**
Gabon	*2.88*	*0.18*	3.06	1.51	*1.52*	*-0.57*	*0.40*	*1.22*	*2.56*	*0.42*	2.98	**7.56**
Ghana	*7.55*	*1.37*	8.92	3.04	*-0.22*	*-0.04*	*-0.77*	*-1.57*	*-2.60*	*0.92*	-1.68	**10.29**
Guinea	*4.35*	*0.40*	4.75	0.91	*-0.08*	*-0.59*	*-0.68*	*-0.05*	*-1.40*	*-0.32*	-1.72	**3.94**
Kenya	*6.56*	*1.37*	7.92	1.36	*-0.04*	*-0.25*	*-0.44*	*-1.13*	*-1.86*	*0.62*	-1.24	**8.04**
Madagascar	*4.18*	*0.62*	4.80	2.43	*0.15*	*0.09*	*-0.31*	*-0.70*	*-0.77*	*-0.21*	-0.98	**6.25**
Malawi	*5.93*	*1.15*	7.08	1.10	*0.01*	*-0.19*	*-0.21*	*-0.52*	*-0.91*	*-0.13*	-1.04	**7.14**
Morroco	*4.78*	*1.49*	6.28	2.54	*-0.06*	*-0.55*	*-0.16*	*-0.31*	*-1.09*	*0.41*	-0.68	**8.14**
Mozambique	*4.68*	*0.68*	5.36	3.19	*-0.09*	*1.04*	*-0.23*	*-2.07*	*-1.34*	*-0.79*	-2.14	**6.42**
Namibia	*6.09*	*2.30*	8.39	2.28	*0.14*	*0.79*	*-0.05*	*0.01*	*0.89*	*-2.16*	-1.27	**9.40**
Rwanda	*6.53*	*0.68*	7.21	1.71	*0.00*	*-0.30*	*0.00*	*-0.64*	*-0.94*	*0.11*	-0.83	**8.09**
Senegal	*5.24*	*1.02*	6.26	1.80	*-0.05*	*-1.51*	*-0.27*	*-0.75*	*-2.57*	*1.41*	-1.16	**6.90**
South Africa	*4.79*	*1.64*	6.44	1.32	*0.02*	*-0.11*	*0.40*	*0.01*	*0.32*	*-0.54*	-0.22	**7.54**
Tunisisa	*4.65*	*0.99*	5.64	1.46	*0.08*	*-0.22*	*-0.13*	*-0.33*	*-0.59*	*0.18*	-0.42	**6.68**
Uganda	*5.98*	*0.82*	6.80	1.89	*-0.11*	*0.02*	*-0.15*	*-0.84*	*-1.09*	*0.04*	-1.05	**7.64**
Zambia	*5.80*	*1.56*	7.36	2.34	*-0.04*	*-0.01*	*0.52*	*-0.35*	*0.12*	*0.63*	0.75	**10.44**
all	*4.76*	*1.03*	**5.79**	**1.87**	*0.12*	*-0.04*	*0.07*	*-0.29*	*-0.14*	*-0.15*	**-0.29**	**7.37**

Table B.2: Contribution of GDP components to GDP growth 1985-1999

Country	Averaged contribution (in %) to nominal GDP growth of											Growth rate (in %) of nominal GDP
	Household final consumption expenditure	*General government final consumption expenditure*	**Final consumption expenditure**	**Gross capital formation**	*EU*	*USA*	*China*	*Rest of the world*	***Total net exports of goods***	***Total net exports of services***	**Total net exports of goods and services**	
Algeria	*-0.31*	*-0.10*	-0.41	-0.69	*-0.02*	*-0.03*	*-0.01*	*0.15*	*0.09*	*0.37*	0.46	**-0.64**
Botswana	*3.80*	*3.55*	7.35	3.36	*-0.21*	*0.34*	*0.04*	*0.03*	*0.20*	*1.88*	2.07	**12.79**
Central African Rep.	*1.68*	*0.50*	2.18	0.23	*0.00*	*0.79*	*-0.01*	*0.08*	*0.87*	*-0.95*	-0.08	**2.33**
Congo Dem. Rep.	*-0.71*	*0.05*	-0.66	-0.70	*-0.07*	*0.23*	*-0.16*	*-0.19*	*-0.18*	*0.34*	0.16	**-1.20**
Congo Rep.	*0.56*	*-0.19*	0.37	0.08	*-1.04*	*0.11*	*0.18*	*3.04*	*2.29*	*-0.62*	1.67	**2.12**
Côte d'Ivoire	*4.54*	*0.16*	4.70	0.66	*-0.19*	*-0.07*	*-0.11*	*0.37*	*0.01*	*-0.14*	-0.13	**5.22**
Ethiopia	*-1.31*	*0.41*	-0.90	0.67	*0.12*	*0.01*	*-0.03*	*-0.03*	*0.06*	*-0.44*	-0.37	**-0.60**
Gabon	*2.25*	*-0.16*	2.09	-0.34	*1.79*	*-0.85*	*0.39*	*-0.23*	*1.11*	*0.69*	1.80	**3.55**
Ghana	*3.73*	*0.54*	4.27	1.47	*-0.09*	*-0.09*	*-0.10*	*-0.85*	*-1.13*	*-0.18*	-1.32	**4.43**
Guinea	*3.96*	*0.15*	4.11	1.37	*0.00*	*-0.12*	*-0.09*	*0.09*	*-0.12*	*-0.54*	-0.66	**4.82**
Kenya	*5.68*	*0.98*	6.66	0.64	*-0.05*	*-0.28*	*-0.09*	*-0.07*	*-0.49*	*-0.14*	-0.64	**6.66**
Madagascar	*2.05*	*0.07*	2.12	0.90	*0.10*	*0.34*	*-0.06*	*-0.15*	*0.23*	*-0.42*	-0.19	**2.83**
Malawi	*6.61*	*0.23*	6.84	0.45	*0.20*	*-0.15*	*-0.03*	*-0.98*	*-0.96*	*0.18*	-0.78	**6.51**
Morroco	*5.36*	*1.56*	6.92	2.00	*-0.02*	*-0.13*	*-0.04*	*0.01*	*-0.19*	*0.14*	-0.05	**8.87**
Mozambique	*2.42*	*-0.18*	2.25	1.80	*0.15*	*0.27*	*-0.03*	*-2.13*	*-1.74*	*0.93*	-0.81	**3.24**
Namibia	*4.43*	*2.33*	6.76	2.19	*-0.31*	*0.90*	*-0.01*	*0.22*	*0.81*	*-2.70*	-1.90	**7.05**
Rwanda	*3.47*	*0.67*	4.14	0.59	*-0.15*	*-0.15*	*0.03*	*-0.26*	*-0.52*	*0.75*	0.23	**4.97**
Senegal	*4.07*	*0.64*	4.71	0.76	*0.00*	*-0.66*	*-0.04*	*-0.29*	*-0.99*	*0.91*	-0.08	**5.38**
South Africa	*3.81*	*1.07*	4.88	0.68	*-0.06*	*-0.07*	*-0.01*	*0.18*	*0.05*	*-0.07*	-0.02	**5.54**
Tunisisa	*4.91*	*1.20*	6.11	1.57	*0.06*	*-0.37*	*-0.02*	*-0.24*	*-0.57*	*0.53*	-0.04	**7.64**
Uganda	*5.37*	*0.58*	5.95	1.40	*-0.17*	*0.23*	*-0.01*	*-0.78*	*-0.73*	*-0.39*	-1.13	**6.22**
Zambia	*4.55*	*-0.20*	4.36	0.31	*0.02*	*0.13*	*-0.27*	*-0.28*	*-0.40*	*0.25*	-0.15	**4.51**
all	*3.22*	*0.63*	**3.85**	**0.88**	*0.00*	*0.02*	*-0.02*	*-0.10*	*-0.11*	*0.02*	**-0.09**	**4.65**

Table B.3: Contribution of GDP components to GDP growth 2000-2012

Country	Averaged contribution (in %) to nominal GDP growth of											Growth rate (in %) of nominal GDP
	Household final consumption expenditure	*General government final consumption expenditure*	**Final consumption expenditure**	**Gross capital formation**	*EU*	*USA*	*China*	*Rest of the world*	***Total net exports of goods***	***Total net exports of services***	**Total net exports of goods and services**	
Algeria	*2.87*	*2.05*	4.91	4.76	*1.19*	*1.07*	*-0.23*	*0.57*	*2.60*	*0.23*	2.83	**12.50**
Botswana	*4.87*	*1.08*	5.95	3.42	*0.17*	*2.32*	*-0.13*	*0.26*	*2.61*	*-3.34*	-0.73	**8.64**
Central African Rep.	*6.70*	*-0.16*	6.54	0.76	*-0.06*	*-1.42*	*0.13*	*-0.67*	*-2.01*	*1.17*	-0.84	**6.46**
Congo Dem. Rep.	*7.39*	*1.92*	9.31	3.78	*-0.25*	*-1.14*	*2.01*	*-1.11*	*-0.49*	*-1.74*	-2.23	**10.86**
Congo Rep.,	*3.63*	*1.91*	5.54	3.60	*3.58*	*0.60*	*6.54*	*1.55*	*12.26*	*-3.54*	8.72	**17.87**
Côte d'Ivoire	*5.68*	*0.90*	6.58	0.42	*0.33*	*0.62*	*-0.16*	*0.22*	*1.01*	*-0.29*	0.72	**7.72**
Ethiopia	*11.79*	*0.93*	12.73	5.03	*-0.45*	*-0.14*	*-0.59*	*-1.25*	*-2.42*	*-0.78*	-3.21	**14.55**
Gabon	*3.99*	*0.76*	4.76	3.51	*1.23*	*-0.27*	*0.40*	*2.78*	*4.13*	*0.13*	4.26	**12.53**
Ghana	*11.68*	*2.25*	13.93	4.73	*-0.37*	*0.02*	*-1.49*	*-2.35*	*-4.18*	*2.11*	-2.06	**16.59**
Guinea	*4.78*	*0.67*	5.45	0.43	*-0.16*	*-1.05*	*-1.28*	*-0.20*	*-2.69*	*-0.10*	-2.79	**3.08**
Kenya	*7.50*	*1.78*	9.29	2.13	*-0.04*	*-0.21*	*-0.81*	*-2.27*	*-3.32*	*1.44*	-1.89	**9.53**
Madagascar	*4.16*	*1.43*	5.59	3.12	*-0.12*	*-1.01*	*-0.29*	*-0.65*	*-2.07*	*0.71*	-1.36	**7.35**
Malawi	*4.98*	*2.23*	7.21	2.02	*-0.18*	*-0.24*	*-0.33*	*-0.02*	*-0.78*	*-0.57*	-1.35	**7.87**
Morroco	*7.15*	*1.27*	8.42	4.57	*0.20*	*-0.17*	*-0.58*	*-1.30*	*-1.85*	*-0.05*	-1.90	**11.09**
Mozambique	*7.11*	*1.61*	8.72	4.69	*-0.35*	*1.87*	*-0.44*	*-2.00*	*-0.92*	*-2.65*	-3.56	**9.85**
Namibia	*7.89*	*2.25*	10.14	2.37	*0.63*	*0.67*	*-0.08*	*-0.21*	*1.00*	*-1.59*	-0.60	**11.92**
Rwanda	*9.82*	*0.69*	10.50	2.92	*0.15*	*-0.46*	*-0.04*	*-1.06*	*-1.40*	*-0.57*	-1.97	**11.46**
Senegal	*6.51*	*1.42*	7.93	2.92	*-0.09*	*-2.42*	*-0.52*	*-1.24*	*-4.28*	*1.96*	-2.32	**8.53**
South Africa	*5.85*	*2.26*	8.11	2.01	*0.10*	*-0.15*	*0.59*	*-0.17*	*0.37*	*-0.80*	-0.43	**9.69**
Tunisisa	*4.37*	*0.77*	5.14	1.33	*0.10*	*-0.06*	*-0.24*	*-0.43*	*-0.62*	*-0.21*	-0.83	**5.64**
Uganda	*6.69*	*1.10*	7.79	2.47	*-0.05*	*-0.22*	*-0.29*	*-0.91*	*-1.47*	*0.52*	-0.96	**9.30**
Zambia	*7.25*	*3.60*	10.86	4.71	*-0.10*	*-0.16*	*1.37*	*-0.43*	*0.68*	*1.12*	1.80	**17.36**
all	*6.48*	*1.49*	**7.97**	**2.99**	*0.25*	*-0.09*	*0.16*	*-0.50*	*-0.17*	*-0.31*	**-0.49**	**10.47**

Chapter 3
The Relationship between Public Debt and Economic Growth: Nonlinearity and Country-Specificity

1. Introduction

Over the past decade, and in particular in the aftermath of the economic and financial crisis that started in 2008, fiscal sustainability has deteriorated markedly in many European countries (see European Commission's Debt Sustainability Monitor 2016 (2017)). This reflects large current fiscal deficits, high levels of debt, forecasts of moderate to low GDP growth, which comes in addition to the huge future costs of an ageing population that is projected to have considerable fiscal implications in most countries. The economic and financial crisis of 2008 and the difficulties related to the expansion of the public debt in industrial countries led to a substantial worsening of public finances in many advanced countries and, consequently, to a renewed interest in the relation between public debt and economic growth among policy-makers and economists. Indeed, a good understanding of the relation between debt and growth is crucial for an adequate guidance of public policies.

In order to achieve development and growth, a country needs resources. A country may be able to generate some of them domestically but often it needs to borrow from the international capital market, which can lead to high levels of debt. The theoretical models exploring the debt-growth relationship can be grouped in three types. The first type of models, neo classical growth models, claim that a reasonably (low) level of debt stimulates growth (through, for instance, an increase of disposable income and of aggregate demand); public debt has a positive impact on GDP growth due to the stimulus effects of fiscal policy. The second type of models (see Krugman (1988) for instance), which support the debt overhang hypothesis, argue that a very large debt stock has detrimental effects on growth. For instance, it can create higher future taxes and/or interest rates that will negatively influence growth in investment and consumption, which in turns will result in less employment and lower output growth. The final type of models combines these two ideas and states that there is a nonlinear debt-growth relationship (see Pattillo et al. (2002) for instance). This view suggests that in the early stages of borrowing, when the debt level is modest, debt enhances growth while in the later stages, when debt is too high, it inhibits growth. This would imply that there is a critical debt threshold below which debt enhances growth but above which debt deters growth.

Since the latest global debt crisis and in particular the analysis of Reinhart and Rogoff (2010a,b), most empirical papers on the debt-growth topic take as given the nonlinear nature of the debt-growth relationship and consider a common debt-to-GDP threshold among countries. However, several authors have recently questioned these premises. According to Egert (2015a, 2015b) and Panizza and Presbitero (2013), the presence and the level of the estimated thresholds are not robust to small changes in country coverage, empirical techniques and/or frequency of data. Regarding the relations between debt and growth, Herndon et al. (2014) suggest that there is no nonlinearity and Kourtellos et al. (2013) find that there is little evidence supporting nonlinearity. Furthermore, the literature on this topic also indicates that the impact of debt on economic growth is not necessarily positive below the debt-threshold and negative above it. For example, Chang and Chiang (2012) find that this effect is positive in both regimes (further examples are given by Dafermos (2015)). Misztal (2010) and Bell et al. (2015), who analyzed developed countries, as well as Eberhardt and Presbitero (2015), who worked on developing, emerging and developed economies, conclude that the relation between public debt and growth is heterogeneous among countries. Eberhardt (2013) enumerates various reasons that would justify why the link between debt and growth might differ among countries; it depends on variables such as the income level or debt composition, on the reasons why debt has been accumulated, on whether debt has been consumed or invested (if so, in which economic activities) and/or on the capacity of the country to tolerate high amounts of debt, which might be influenced by its macroeconomic and institutional characteristics. However, it is important to note that, with the exception of Egert (2015b) and Eberhardt (2013), none of the recent studies examine the link between public debt and economic growth or the existence of a debt-value threshold for each country individually, which is the aim of the present study.

Our paper contributes to the existing literature in several ways. First, contrary to most papers, we consider the possibility that public debt ratio and GDP per capita might be cointegrated and we perform the appropriate test for this hypothesis by means of the bounds testing procedure developed by Pesaran et al. (2001). Second, we examine the relationship between public debt GDP ratio and economic growth for each country taken separately and test whether it is nonlinear. The possible debt-value threshold is then endogenously estimated following Hansen's (1996, 1999) methodology for each country. Third, contrary to Egert (2015b) and Eberhardt (2013), we perform this analysis while controlling simultaneously for additional determinants of economic growth. Applied to a large dataset of industrial countries, this unique combination of alternative tests and specifications provides a thorough and up-to-date analysis of the controversial link between growth and public debt.

The remainder of this paper proceeds as follow. Section 2 provides a review of the literature on the relation between GDP and debt. Section 3 describes the data as well as the econometric frameworks for testing cointegration between public debt ratio and GDP per capita, examining the relationship between these two variables and determining whether a debt-value threshold exists. Section 4 presents the empirical findings, while section 5 concludes.

2. Literature Survey

We report below the main results of recent studies on the link between public debt and economic growth, which are diverse in terms of data (time and country) coverage and empirical methodology. For reasons of clarity, we divide them into two main groups: the first one for studies in which the debt-value threshold is determined exogenously and the second one for studies in which the debt-value threshold is endogenous.

2.1 Debt threshold determined exogenously

On the basis of correlation statistics between debt and growth, Reinhart and Rogoff (2010a and 2010b) consider 44 countries from the year 1790 to 2009 and conclude that GDP growth rates for countries with public debt over 90% of GDP are significantly lower than if they didn't have such a high level of debt. By means of various time series methods (polynomial functions or piecewise linear (threshold) specifications), Eberhardt (2013) analyzes two centuries of data for four industrialized countries and finds no evidence for a linear or a nonlinear long-run relationship between debt and growth. His results also show that this link varies across countries. In their study, Eberhardt and Presbitero (2013) analyze a panel of 105 countries over the period 1972 to 2009. They take into account nonlinearities in both the cross-country and within-country dimensions by means of heterogeneous dynamic ECM within a standard growth model and static regression models with squared and cubed debt terms. They test the existence of three possible debt (% GDP) threshold values: 52% (the sample median), 75% and 90%. They find some support for a nonlinear relationship between debt and long-run growth across countries, but no evidence supporting a common debt threshold within countries over time. Afonso and Alves (2014) consider 14 European countries over the 1970-2012 period. They study the effect of public debt on economic growth and on the basis of quadratic models, the authors find that average debt ratio thresholds lie around 75% depending on the econometric method used and on the set of variables. After having identified and corrected several errors in Reinhart and Rogoff (2010a,b), Herndon et al. (2014) replicated these authors' much cited analysis and in contrast find that average GDP growth at public debt/GDP ratios over 90 percent is not dramatically different than when debt/GDP ratios are lower. They also show that the debt-growth relation vary among countries and time periods. By means of panel vector autoregressions, Lof and Malinen (2014) analyze data on 20 developed countries over the period 1905–2008 and find no evidence for a robust effect of debt on growth, even for higher levels of debt. In addition they come to the conclusion that this effect is ambiguous. On the basis of the data used by Reinhart and Rogoff (2010a), Bell et al. (2015) examine the link between growth and debt in developed countries. The authors use multilevel models and find that the debt-growth link vary across countries and that the explanatory power of debt on growth is poor. Eberhardt and Presbitero (2015) database includes data from 1961 to 2012 for 118 countries. Their linear and nonlinear regression models take into account heterogeneity across the considered countries through a common correlated effects (CCE) estimator. The authors test the presence of prespecified debt GDP ratio threshold value (60% and 90%) and find some support for a negative relationship between public debt and long-run growth across countries, but do not report any evidence for a common debt threshold within countries. Kumar and Woo (2015) analyze the impact of high public debt on long-run economic growth in 38 advanced and emerging economies over 38 years (1970-2007) using growth regressions. In order to analyze potential nonlinearities, they include in the specifications interaction terms between initial debt and dummy variables for various ranges of initial debt. Their result suggest an inverse relation between initial debt and subsequent growth and some evidence of nonlinearity, according to which high levels of debt (above 90% of GDP) have a significant negative effect on growth.

2.2 Debt threshold determined endogenously

This category of studies is further divided into two sub-groups. The first one describes the studies in which the debt-value threshold is determined by means of the Hansen’s (1996, 1999) methodology, which is used in this paper and described in details in Section 3 below. In addition to allow the determination of the threshold's level endogenously, this methodology has several advantages. It allows to estimate simultaneously the threshold level, the coefficients of the different regimes and the ones of the other explanatory variables by OLS. This methodology also allows the calculation of an asymptotic p-value for the null hypothesis of no threshold effect (i.e. linearity) using simple simulation techniques. In addition, it can also be mentioned that this technique doesn't impose any specific functional form of nonlinearity for the analyzed relationship (Nasa (2009)). The papers using other techniques are listed in the second sub-group.

2.2.1 Studies using Hansen threshold methodology (1996, 1999)

Nasa (2009) attempts to endogenously determine the sustainable level of debt for 56 low and medium income countries over the period 1970-2000. The results suggest that debt becomes detrimental to growth once the debt-to-GDP ratio is greater or equal to 45% and that a debt-to-GDP ratio of 7% is the growth maximizing level of debt. Caner et al. (2010) consider 99 developing and developed countries over the period 1980-2008 in order to find the tipping point when public debt starts to have a negative impact on economic growth. They find that if the debt-to-

GDP ratio is above 77%, each additional percentage point of debt creates a decrease of 0.017 percentage points of real growth. Their results also indicate that this effect is stronger in developing countries, where the threshold amounts to 64% debt-to-GDP ratio. Considering a panel of 18 OECD countries over 1980 to 2010, Cecchetti et al. (2011) use a panel threshold approach inspired by Hansen (1999). They find that when the level of government debt is higher than 85% of GDP, the debt has a negative impact on economic growth. Afonso and Jalles (2013) use a panel of 155 developed and developing countries over the period 1970-2008. They estimate growth equations as well as the debt threshold. The authors find that economic growth is lower when the value of debt ratio is greater than 59%. Baum et al. (2013) analyze the nonlinear impact of public debt on GDP growth by extending the threshold panel methodology by Hansen (1999) to a dynamic setting. They focus on 12 European countries for the period 1990-2010. Their results suggest that the short-run impact of debt on GDP growth is positive and statistically significant. However, beyond the public debt-to-GDP ratios of 67%, the short-run impact decreases to zero and is not statistically significant any more. Egert (2015a) considers 44 countries and two periods i.e. 1790 to 2009 or 1946 to 2009 (dataset of Reinhart and Rogoff (2010a)). On the basis of bivariate regressions, the author finds some evidence of a negative nonlinear relation between debt and growth with a debt threshold lying between 20% and 60% of GDP. However, the author clearly points out that these results, including the nonlinearity of the link between public debt and growth, are not robust. Egert (2015b) uses the same dataset as Reinhart and Rogoff (2010a) and estimates bivariate threshold models. The results indicate that the nonlinear relation between debt and growth is not robust. There might be a tipping point at around 20% of GDP but this outcome must be considered with caution. In order to consider that the impact of public debt on economic growth might be country-specific, Egert (2015b) performs the same analyses for individual countries, which reveal that cross-country heterogeneity is very important. Swamy (2015a) considers 252 countries over the period 1960-2009 in order to analyze the relationship between government debt and economic growth. The author groups the countries according to various criteria such as the type of political governance or the level of income. The findings show that the debt thresholds may vary between 84 and 114 percent of GDP according the different groups of countries and that above the debt-threshold, an increase of debt is detrimental to economic growth. Among all the studies listed in Section 2.2.1, Egert (2015b) is the only one who uses time series estimation techniques and his analysis is the most closely related to the present paper. However, one must note that this author only estimates bivariate specifications, as public debt is the only explanatory variable for GDP growth.

2.2.2 Studies using other methodologies

Chang and Chiang (2012) use a Panel Smooth Transition Regression (PSTR) model to analyze 19 OECD countries over the period 1993-2007. They find that there is one threshold value of 97.82% above which growth is lower than if the level of debt was under the threshold value. However, they also conclude that the impact of debt on GDP growth is positive on both sides of the threshold. Checherita-Westphal and Rother (2012) investigate the average impact of government debt on per-capita GDP growth in 12 European countries over a period of around 40 years starting in 1970. They perform growth regressions quadratic in debt and control for various growth determinants. Their results indicate that the impact of debt on growth is nonlinear with a turning point – beyond which the government debt-to-GDP ratio has a negative impact on long-term growth – at about 90-100% of GDP. Minea and Parent (2012) use a PSTR method in order to check the relevance of the debt-to-GDP ratio threshold of 90% found by Reinhart and Rogoff (2010b). The authors consider 20 advanced economies over the period 1945 to 2009. Like Reinhart and Rogoff (2010b), they find that a debt-to-GDP ratio above 90% reduces average economic growth but that this contraction of economic growth is not statistically significant. They also find that when debt-to-GDP ratio is above 115%, the impact of public debt on GDP can be positive. Presbitero (2012) explores the impact of public debt on growth for a panel of 92 developing countries over the period 1990-2007. The author uses growth equations estimated by System GMM and models nonlinearities in three different ways: quadratic functional form, spline specification and interaction of public debt with the overall Country Policy and Institutional Assessment (CPIA) score (which takes into account the role of policies and institutions on economic development). This study shows that public debt has a negative impact on output growth up to a threshold of 90% of GDP, beyond which its effect is irrelevant. In their study, Kourtellos et al. (2013) analyze a panel of 82 countries covering the period 1980 to 2009. They use a structural threshold regression methodology and find that there is little evidence of nonlinearity between public debt and growth. Furthermore, their results suggest that the link between these two variables depends on the quality of the institutions of the studied countries. Swamy (2015b) investigates the government debt – growth relationship for several groups of countries and take into account economic, political and regional diversities. On the basis of a dataset containing 252 countries over the period 1960-2009, considering a quadratic functional form and by means of several different panel data models, the author finds that the link between debt and growth is negative and nonlinear. Using dynamic heterogeneous panel data models with cross-sectionally dependent errors, Chudik et al. (2017) analyze the relation between public debt and economic growth. The authors consider 40 advanced and developing countries over the 1965 to 2010 period and find that public debt has negative long-run effects on economic growth and that there is no evidence for a universal threshold effect in the relationship between these two variables.

3. Methodology

The purpose of this paper is to study the relationship between public debt GDP ratio and economic growth. The estimation's procedure consists in several steps. First, the possible cointegration between public debt GDP ratio and GDP per capita growth is tested by means of the bounds testing approach developed by Pesaran et al. (2001). This methodology has the advantage that, contrary to the Engle and Granger (1987) procedure, it can be applied even if the variables are not integrated of the same order. The order of integration must however not be higher than 1. Once the autoregressive distributed lag (ARDL) linear model (i.e. without threshold effects) resulting from the bounds testing approach has been determined, the corresponding threshold model is estimated following Hansen's (1996, 1999) methodology. As mentioned above, the latter has several advantages. The threshold's level is determined endogenously and is simultaneously estimated with the coefficients of all the variables included in the specification. The different equations are estimated by OLS and this methodology also allows the calculation of an asymptotic p-value for the null hypothesis of no threshold effect using simple simulation techniques. In addition, contrary to the estimation of quadratic specification for instance, this technique doesn't impose any specific functional form of nonlinearity for the analyzed relationship. The next step of the estimation's procedure consists in testing the threshold model against the linear model using a bootstrapping method developed by Hansen (1996). Finally, we test for the significance of the threshold by means of a likelihood ratio (LR)-type statistic[1].

3.1 Cointegration test and linear model

In order to test whether real GDP per capita growth and public debt GDP ratio are cointegrated, the bounds testing procedure developed by Pesaran et al. (2001) is used. This approach has the advantage that it is not necessary for the variables of interest to be integrated of the same order. However, the latter must be lower than 2. In this study, the integration order of the variables is determined by means of the augmented Dickey-Fuller (ADF) test[2]. Various growth determinants (denoted by x_2 to x_m) are introduced in the econometric specification in order to improve the

[1] Although encompassing in a single framework most of the empirical caveats identified by the literature, our methodology does not test for the presence of a threshold in the equilibrium correction mechanism itself. This implies that the long-run equation is assumed to remain identical whatever the level of the public debt ratio and that only short-run asymmetries are considered (as in Mehrara et al. (2010) or Bastianin et al. (2014), for example). Ideally, both long-run and short-run asymmetries should be simultaneously tested. However, to our knowledge, no methodology allowing to perform these two tests simultaneously currently exists and developing one would be beyond the scope of the present paper.

[2] The null hypothesis is that the series has a unit root.

fit of the model. In order to perform bounds testing, we follow the procedure described by Giles (2013). If the variables' integration order is lower than 2, the following equation is formulated:

$$\begin{aligned}\Delta GDP_t = c + \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + \\ + \theta_0 GDP_{t-1} + \theta_1 debt_{t-1} + \theta_2 x_{2,t-1} + \ldots + \theta_m x_{m,t-1} + e_t\end{aligned} \tag{1}$$

where Δ indicates the first difference operator, GDP real GDP per capita growth (the dependent variable), *debt* the public debt to GDP ratio, *k* and *l* the autoregressive order of these two variables and e_t the error term (independent and identically distributed with mean zero and finite variance). Equation (1) represents the "conditional" ECM (see Pesaran et al. (2001) p. 292), which is a particular type of ARDL model, and will be used to perform the cointegration test.

We begin this test procedure by determining the optimal number of lags of the two variables of interest according to the Schwarz (Bayes) criterion (SC). In this study, as the number of observations is relatively low, the maximum number of lags of the two variables of interest is limited to 2. Furthermore, only the contemporaneous value of each additional right-hand-side variables is considered[3]. The next step consists in testing the possible serial correlation of the errors. For this purpose, we refer to the Breusch-Godfrey Serial Correlation LM test. Finally, it is necessary to test whether the ARDL model is stable. This consists in checking that all the inverse roots of the characteristic equation associated with our model lie strictly inside the unit circle[4]. After having performed these tests, the bounds testing procedure can be applied by performing an "F-test" of the hypothesis H_0: $\theta_0 = \theta_1 = \theta_2 = \ldots = \theta_m = 0$ (against the alternative that H_0 is rejected). As explained by Giles (2013),"this corresponds to, like in conventional cointegration testing, a test for the absence of a long-run equilibrium relationship between the variables". Thus, a rejection of H_0 implies that we have a long-run relationship. For small samples, which is the case in this study, it is appropriate to refer to the bounds on the critical values of the F-statistic provided by Narayan (2005).

[3] If we let vary the number of lags of the additional growth determinants, the number of explanatory variables can be up to 32 in equation (1). As the number of observations is around 40, the number of degrees of freedom would be too low. Furthermore, this would imply that in the threshold specification (see equations (5) and (6) the number of parameters could be higher that the number of observations).

[4] If the errors are not serially independent or the ARDL model is not stable, the optimal number of lags are determined according to the second lowest value of the SIC criterion, and so on.

If the bounds test leads to the conclusion of cointegration, the long-run equilibrium relationship between the variables can be estimated by the following equation:

$$GDP_t = \tau + \rho debt_t + \partial_2 x_{2,t} + \ldots + \partial_m x_{m,t} + \upsilon_t \tag{2}$$

The corresponding usual ECM is:

$$\Delta GDP_t = \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \varphi \hat{z}_{t-1} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + e_t \tag{3}$$

where $\hat{z}_{t-1} = GDP_{t-1} - \hat{\tau} - \hat{\rho} debt_{t-1} - \hat{\partial}_2 x_{2,t} - \cdots - \hat{\partial}_m x_{m,t}$ and is the error correction term[5]. The magnitude of the coefficient of the error term represents the percentage at which any disequilibrium between GDP and the right-hand-side variables is corrected within one period. In order to validate this "final" ECM model, the coefficient of the error correction term must lie between -1 and 0 and be statistically significant[6].

If there are no statistically significant long-run effects or if the ECM is not validated, the final model is (see Marques et al. (2016) for example):

$$\Delta GDP_t = \xi + \sum_{i=1}^{k} \alpha_i \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j \Delta debt_{t-j} + \kappa_2 \Delta x_{2,t} + \ldots + \kappa_m \Delta x_{m,t} + \mu_t \tag{4}$$

Whatever the case, i.e. whether the final model is given by equation (3) or (4), the model must be stable and the errors serially independent[6].

One must note that the link between the different variables may not be linear. This calls for further investigation, as illustrated in the following subsection.

3.2 Threshold model

In order to estimate the possible asymmetric relation between real GDP per capita growth and public debt ratio, a threshold autoregressive (TAR) mechanism is added to the linear model. The resulting model is referred to as the TAR specification (when the ECM representation is validated, it is referred to as the TAR-ECM specification). The TAR (-ECM) model assumes that the regime is determined by a variable, here $debt_t$, relative to a threshold value. If the relation between real GDP per capita growth and public debt ratio is asymmetric, the impact of the latter variable would be different in each regime. A two-regime TAR-ECM has the following form:

[5] It represents the speed at which the dependent variable returns to its long-run equilibrium value after a change in the independent variable.

[6] If the model is not stable or if the errors are not serially independent, the optimal number of lags are determined according to the second lowest value of the SIC criterion, and so on.

$$\Delta GDP_t = \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \varphi \hat{z}_{t-1} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + \\ + \left(\sum_{j=0}^{l} b_j^* \Delta debt_{t-j}\right) 1\left(debt_t > \bar{d}\right) + e_t \qquad (5)$$

Grasso and Manera (2007 / p. 11) explain that in equation (5), $debt_t$ "is the threshold variable, which is a continuous and stationary transformation of the data, and $\bar{d} \in \Gamma$ is the threshold parameter (in the linear model, it is equal to zero)". The authors further indicate that "the region denoted by Γ is typically selected by sorting the observations on the threshold variable into an increasing order; the resulting model is well identified for all possible thresholds. The error term e_t is assumed to be independent and identically distributed with mean zero and finite variance. The function *1()* indicates whether or not the threshold variable is above the threshold". Similarly to Baum et al. (2013), we consider the possible change of coefficients in the different regimes only for public debt to GDP ratio. This implies that the slope of the other variables remain the same in each regime. The regression coefficients are $(a_i, b_j, \phi, \partial_2, \ldots, \partial_m)$ if $debt_t \leq$d, and $(a_i, b_j+b_j^*, \phi, \partial_2, \ldots, \partial_m)$ if $debt_t >$d. The coefficients of the first group correspond to the regime of lower values of $debt_t$ and those of the second group correspond to the regime of upper values of $debt_t$.

If the ECM representation is not validated, the corresponding TAR equation is the following:

$$\Delta GDP_t = \xi + \sum_{i=1}^{k} \alpha_i \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j \Delta debt_{t-j} + \kappa_2 \Delta x_{2,t} + \ldots + \kappa_m \Delta x_{m,t} + \\ + \left(\sum_{j=0}^{l} \beta_j^* \Delta debt_{t-j}\right) 1\left(debt_t > \bar{d}\right) + \mu_t \qquad (6)$$

In this case, the coefficients of the lower regime are $(\zeta, \alpha_i, \beta_j, \kappa_2, \ldots, \kappa_m)$ and the ones of the upper regime are $(\zeta, \alpha_i, \beta_j+\beta_j^*, \kappa_2, \ldots, \kappa_m)$.

In the robustness test section, we will consider a possible change of the coefficients of all the explanatory variables in the different regimes. In that case, the two-regime TAR-ECM has the following form:

$$\Delta GDP_t = \sum_{i=1}^{k} a_i \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j \Delta debt_{t-j} + \varphi \hat{z}_{t-1} + \partial_2 \Delta x_{2,t} + \ldots + \partial_m \Delta x_{m,t} + \\ + \left(\sum_{i=1}^{k} a_i^* \Delta GDP_{t-i} + \sum_{j=0}^{l} b_j^* \Delta debt_{t-j} + \varphi^* \hat{z}_{t-1} + \partial_2^* \Delta x_{2,t} + \ldots + \partial_m^* \Delta x_{m,t}\right) 1\left(debt_t > \bar{d}\right) + e_t \qquad (7)$$

The regression coefficients are $(a_i, b_j, \phi, \partial_2, \ldots, \partial_m)$ if $debt_t \leq$d, and $(a_i+a_i^*, b_j+b_j^*, \phi+\phi^*, \partial_2+\partial^*_2, \ldots, \partial_m+\partial^*_m)$ if $debt_t >$d. If the ECM representation is not validated, the corresponding TAR equation is the following:

$$\Delta GDP_t = \xi + \sum_{i=1}^{k} \alpha_i \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j \Delta debt_{t-j} + \kappa_2 \Delta x_{2,t} + \ldots + \kappa_m \Delta x_{m,t} + \\ + \left(\xi^* + \sum_{i=1}^{k} \alpha_i^* \Delta GDP_{t-i} + \sum_{j=0}^{l} \beta_j^* \Delta debt_{t-j} + \kappa_2^* \Delta x_{2,t} + \ldots + \kappa_m^* \Delta x_{m,t}\right) 1\left(debt_t > \bar{d}\right) + \mu_t \qquad (8)$$

The regression coefficients are $(\zeta,\ \alpha_i,\ \beta_j,\ \kappa_2,\ \ldots,\ \kappa_m)$ if $debt_t$ ≤d, and $(\zeta+\zeta^*, \alpha_i+\alpha_i^*, \beta_j+\beta_j^*, \kappa_2+\kappa^*_2, \ldots, \kappa_m+\kappa^*_m)$ if $debt_t$ >d.

As mentioned by Mehrara et al. (2010 / p. 7), "the threshold value $\bar{d}$ is unknown and should be estimated in addition to other parameters of the TAR(-ECM) model". The authors also refer to Chan (1993) who showed that, since the threshold equation is nonlinear and discontinuous, the parameter estimates can be obtained by sequential conditional least squares. This procedure consists in running least squares regressions on equations (5) and (6), as well as on (7) and (8), using all possible values of the threshold ($\bar{d}\in\Gamma$) and selecting the threshold's estimate, $\hat{\bar{d}}$, as the argument that minimizes the sum of squared residuals, denoted by S($\bar{d}$), i.e.: $S\left(\hat{\bar{d}}\right) = \inf_{\bar{d}\in\Gamma} S(\bar{d})$.

3.2.1 Test of the threshold model against the linear model

The next step consists in testing the threshold model (equations (5) or (7) and (6) or (8)) relative to the corresponding linear model (equations (3) and (4)). Referring to the description of Grasso and Manera (2007), the null hypothesis (linearity) is H_0: $b_0^* = b_1^* = \cdots = b_m^* = 0$ when the error correction mechanism is validated. When the error correction mechanism is not validated, the null hypothesis is H_0: $\beta_0^* = \beta_1^* = \cdots = \beta_m^* = 0$. The test statistic for linearity is:

$$F = T(\tilde{S} - S(\hat{\bar{d}}))/S(\hat{\bar{d}}) \qquad (9)$$

with *S* being the estimated residual variance of the corresponding linear model. As noted by Grasso and Manera (2007 / p. 162), "the distribution of *F* in expression (9) is non-standard, as the threshold is not identified under the null hypothesis of linearity". We follow these authors and apply the bootstrapping procedure developed by Hansen (1996) to approximate the asymptotic distribution of *F*. On a total of *1000* bootstrap samples, the asymptotic p-value is the share of bootstrap samples for which the bootstrap statistic exceeds *F*.

3.2.2 Test of the significance of the threshold

In order to examine the statistical significance of the threshold estimate, we consider the null hypothesis H_0: $\overline{d_0} = \bar{d}$, where $\overline{d_0}$ is the true value and $\bar{d}$ is a generic value, and we use a likelihood ratio-type statistic[7]:

$$LR(\bar{d}) = T(S(\bar{d}) - S(\hat{\bar{d}}))/S(\hat{\bar{d}}) \tag{10}$$

where T is the number of observations, $\hat{\bar{d}}$ is the threshold that minimizes the sum of squared residuals in equations (5) to (8) (i.e. the estimated threshold) and $\bar{d}$ is a generic value of the threshold. This statistic is compared with the critical value tabulated in Hansen (2000)[8] as this likelihood ratio (LR) test does not have the usual χ^2 distribution. The confidence interval (CI) for the estimated threshold can be found graphically by plotting the LR sequence in $\bar{d}$, LR($\bar{d}$), against $\bar{d}$ and drawing a horizontal line at the desired level of asymptotic critical values provided by Hansen (2000). The portion of the graph lying below the horizontal line is the "no rejection" region, i.e. the CI of the point estimate. The threshold point is where the LR is minimized and the CI occurs where the horizontal line crosses the curve. However, when the critical values lay above all the calculated LR statistics, it is not possible to compute the intervals for the threshold.

4. Empirical results

4.1 Data

In this study, we use data from 17 industrialized countries over the period 1970 - 2014. The considered variables are the general government consolidated gross debt (percentage of GDP), real GDP per capita in (constant 2005) US dollars[9], gross fixed capital formation (GDP ratio, as a proxy for domestic investment), openness to trade (defined as the sum of exports and imports over (nominal) GDP), inflation (GDP deflator), general government final consumption expenditure (% of GDP), population growth, and school enrollment at the secondary level (% gross). See Appendix A and table D.1 in the Appendix D for the variables definition and for each country's data summary. All data are available from the World Bank (World Development Indicators database) except the series for the general government consolidated gross debt, which come from Eurostat (the Statistical Office of the

[7] By definition this statistic equals zero at the estimated threshold level.

[8] The critical value for the 95% and the 99% are 7.35 and 10.59 (see Hansen (2000) Table 1, page 582).

[9] The variable "GDP, Purchasing Power Parity (PPP) (constant international $)" was not available for the considered period for each analyzed country. However, this is inconsequential in terms of growth rates.

European Commission). These explanatory variables are selected according to their availability, as is the choice of the countries considered in the data sample.

4.2 ECM or not?

According to the augmented Dickey-Fuller unit root test, no series has an integration order larger than 1 (see table D.2 in the Appendix). Thus, it is possible to use the bounds testing approach in order to test whether the variables are cointegrated. Table D.3 (see Appendix) lists the optimal number of lags for real GDP per capita and public debt ratio, which is determined according to the Schwarz (Bayes) criterion (SC). As mentioned in section 3.1, the maximum number of lags is 2. However, for Ireland, we let the number of lags be up to 4. Otherwise, it is not possible to get a specification which is stable and has no serial error correlation. In order to test for the presence of serial autocorrelation, the Breusch-Godfrey Serial Correlation LM test is applied (see also table D.3). Finally, the results of the stability test of the model are reported in table D.4[10].

Once these tests have been performed, the cointegration test, which consists in a test of the hypothesis $H_0\colon \theta_0= \theta_1=\theta_2=\ldots=\theta_m=0$ (see equation (1)), can finally be applied[11]. The results are also reported in table D.3 and indicate that for all countries but Ireland the null hypothesis is rejected, which means that there is a long-run relationship between real GDP per capita and public debt ratio. However, after having estimated the usual ECM (see equation (3)) for each country, the results indicate that the error correction specification is finally only validated - i.e. the error correction term[12] is statistically significant and its coefficient lies between -1 and 0[13] - for the following countries: Belgium, Canada, Denmark, Luxembourg and Spain (see table 1 for the long-run equations and table 3 for the corresponding ECM's results). For the other countries, the coefficient of the error correction term is lower than *-1*, which implies that the ECM specification is not validated.

[10] If the errors are not serially independent or if the model is not stable, the optimal number of lags are determined according to the second lowest value of the SIC criterion and so on.

[11] We refer to the tables provided by Narayan (2005) for the bounds on the critical values of the F-statistic.

[12] This term measures the speed at which deviations of the dependent variable from its long-run equilibrium are corrected.

[13] Furthermore, the errors are serially independent.

Table 1: Long-run equations

Dependent variable: Real GDP per capita growth

	Belgium	Canada	Denmark	Luxembourg	Spain
Public debt ratio	-0.038	-0.101	-0.032	0.120	-0.025
	*0.022***	*0.269*	*0.344*	*0.371*	*0.353*
Government consumption	-0.669	-0.126	0.687	-1.216	0.188
	*0.002****	*0.830*	*0.216*	*0.009****	*0.635*
Gross fixed capital formation	-0.159	-0.150	0.148	0.074	0.116
	0.339	*0.565*	*0.531*	*0.799*	*0.797*
Openness to trade	-2.472	1.885	-16.121	1.190	-2.025
	0.342	*0.837*	*0.021***	*0.444*	*0.706*
GDP deflator	-0.308	-0.315	-0.043	-0.666	-0.170
	*0.007****	*0.200*	*0.743*	*0.005****	*0.580*
School enrollment	-0.013	0.036	0.066	-0.009	-0.063
	0.411	*0.820*	*0.108*	*0.895*	*0.244*
Population growth	-70.322	225.097	72.460	-239.190	-194.584
	0.638	*0.293*	*0.714*	*0.020***	*0.467*
Constant	29.644	8.859	-12.246	21.812	7.715
	*0.000****	*0.716*	*0.384*	*0.001****	*0.044***

All the variables are in levels

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

4.3 Linear specifications or threshold?

After having estimated the linear specification (equations (3) and (4)), the (ECM-)TAR model (equations (5) and (6)) is also estimated by OLS[14] for each country. Then, the test of the threshold model relative to the linear model (asymptotic bootstrap p-value) is performed. Table 2 reports for each country the threshold that minimizes the sum of squared residuals, the corresponding F-statistic (equation (9)) and the asymptotic bootstrap p-value. The results indicate that the threshold specification is only validated (p-value lower than 0,1) for four countries (out of 17): Finland, Great Britain, Italy and the Netherlands.

[14] The standard errors are robust to heteroscedasticity.

Table 2: Threshold that minimizes SSR, F statistic and bootstrap p-value

Countries	**Threshold of public debt ratio (% GDP) that minimizes SSR**	**F Statistic**	**Bootstrap p-value[1]**
Austria	26.1	8.1	0.745
Belgium	65.8	8.8	0.696
Canada	70.7	6.8	0.442
Denmark	63.2	3.9	1.000
Finland	**52.2**	**54.4**	**0.003**
France	26.8	15.1	0.187
Great Britain	**50.2**	**21.7**	**0.015**
Greece	21.2	24.6	0.193
Ireland	108.3	9.3	0.998
Italy	**56.3**	**29.9**	**0.090**
Japan	79.9	13.2	0.189
Luxembourg	12.4	7.2	0.936
Portugal	96.2	12.2	0.541
Spain	19.6	13.4	0.259
Sweden	37.6	9.6	0.152
The Netherlands	**48.9**	**22.9**	**0.043**
USA	99.0	7.7	0.399

[1] Generated on the basis of Hansen's (1996) procedure

4.3.1 Results of the linear model

The linear model estimations' results are reported in table 3. They show that the relationship between public debt ratio and economic growth is not the same among countries. This suggests that this link depends, among others, on the country's own characteristics, on its institutions, on the nature and the allocation of public debt, ...

Table 3: Linear specifications

Dependent variable: Real GDP per capita growth (in first differences)

	Austria	Belgium	Canada	Denmark	France	Greece	Ireland	Japan	Luxembourg	Portugal	Spain	Sweden	USA	The Netherlands[1]
Real GDP per capita growth (-1)	-0.246	-0.149	0.071	-0.18	-0.409	-0.403	-0.49	-0.528	-0.259	-0.555	0.042	-0.62	-0.56	-0.641
	0.012**	0.027**	0.375	0.002***	0.004***	0.004***	0.002***	0.000***	0.007***	0.002***	0.722	0.003***	0.001***	0.000***
Real GDP per capita growth (-2)							-0.378	-0.283	-0.188			-0.419		-0.064
							0.028**	0.065*	0.002***			0.008***		0.478
Real GDP per capita growth (-3)							-0.098							
							0.586							
Real GDP per capita growth (-4)							-0.267							
							0.062*							
Public debt ratio	0.108	-0.062	-0.143	-0.059	0.034	-0.11	-0.08	0.254	-0.518	-0.271	-0.261	0.023	0.179	-0.113
	0.186	0.079*	0.031**	0.175	0.755	0.028**	0.385	0.006***	0.000***	0.016**	0.000***	0.84	0.060*	0.042**
Public debt ratio(-1)				0.097	0.26	-0.007	0.063		-0.381	0.259				0.016
				0.008***	0.014**	0.9	0.509		0.002***	0.041**				0.659
Public debt ratio(-2)						0.109	0.04							
						0.182	0.649							
ECT(-1)		-0.946	-0.86	-0.921					-0.898		-0.884			
		0.000***	0.000***	0.000***					0.000***		0.000***			
Government consumption	-2.238	-1.642	-2.188	-0.548	-2.487	-1.833	-2.055	-5.634	-4.332	-0.326	-0.618	-2.098	-3.658	-1.482
	0.073*	0.000***	0.000***	0.024**	0.000***	0.007***	0.009***	0.000***	0.000***	0.65	0.179	0.000***	0.000***	0.003***
Gross fixed capital formation	-0.018	0.136	0.114	1.032	-0.045	0.359	0.107	0.171	0.078	0.359	0.619	0.258	0.683	0.88
	0.965	0.431	0.629	0.000***	0.915	0.297	0.7	0.609	0.452	0.145	0.002***	0.452	0.242	0.011**
Openness to trade	22.316	7.857	8.371	0.459	5.28	-20.963	0.814	20.974	3.645	-1.352	-1.964	12.622	29.253	15.839
	0.014**	0.000***	0.111	0.855	0.362	0.167	0.876	0.027**	0.012**	0.891	0.605	0.129	0.135	0.000***
GDP deflator	-1.466	-0.469	-0.341	-0.129	0.085	-0.333	-0.145	-0.517	-0.467	-0.349	-0.113	0.005	-0.815	-0.576
	0.000***	0.000***	0.000***	0.127	0.631	0.090*	0.308	0.000***	0.000***	0.014**	0.254	0.979	0.001***	0.017**
School enrollment	0.064	-0.011	-0.145	-0.013	0.064	0.041	-0.064	0.113	0.089	-0.14	-0.042	0.005	-0.088	0.104
	0.563	0.155	0.307	0.807	0.248	0.879	0.726	0.71	0.361	0.022**	0.465	0.809	0.504	0.005***
Population growth	-19.099	-101.67	-96.987	524.082	240.111	404.064	144.788	121.104	271.089	-522.895	-171.892	-439.721	-445.862	-154.893
	0.907	0.142	0.188	0.005***	0.001***	0.154	0.252	0.508	0.076*	0.000***	0.097*	0.259	0.124	0.424
Constant	-0.46				-0.536	0.428	-0.384	-0.516		-0.162		0.125	-0.734	-0.291
	0.119				0.055*	0.396	0.358	0.16		0.736		0.714	0.015**	0.089*
Observations	37	41	37	41	35	37	38	38	40	38	41	40	41	37
R-squared	0.75	0.95	0.92	0.94	0.74	0.62	0.72	0.80	0.94	0.64	0.82	0.65	0.69	0.81

All the variables are in first-differences, except the error correction term (ECT)

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

[1] According to the robustness test's results (see section 5.2), the debt-growth relationship in The Netherlands is linear.

Indeed, depending on the country, the impact of the public debt ratio on GDP per capita growth can be positive, negative or not statistically significant. A negative effect of public debt on GDP might be due, for instance, to the fact that higher debt can generate an increase of tax burden which negatively affects the economy's dynamism or leads to a higher interest rate, which would crowd-out investment. According to our results, this effect is observed in Belgium, Canada, Greece, Luxembourg, Portugal[15] and Spain. The influence of public debt might however also be positive as it is the case in Denmark, France, Japan and the USA. This might happen when public debt is efficiently consumed and/or invested. It might then be beneficial for economic growth through a stimulation of employment, consumption or investment, for example (see Eisner (1992)). Regarding Austria, Ireland and Sweden, GDP per capita growth is not influenced by public debt ratio but rather by further economic growth determinants such as government consumption for instance. This heterogeneity among countries suggests that in different economies having a similar level of public debt, the impact of this variable on economic growth will not necessarily be the same because of the influence of several other country-specific factors, including the composition of public debt and the way it is managed by the government. This heterogeneity is highlighted by several authors, such as Panizza and Presbitero (2013), Bell et al. (2015) and Chudik et al. (2017) for example, and suggests that governments must take into account their own countries' specificities in order to be able to shape appropriate fiscal policy measures. Indeed, expansionary fiscal policies do not necessarily have a positive impact on economic activity as other determinants also play a role in this relationship.

4.3.2 Results of the threshold model

As mentioned above, the threshold specification is validated for only four countries (out of 17), which are Finland, Great Britain, Italy and The Netherlands. The results presented in table 2 show that the debt-value threshold is different for each of these countries, which confirms, among others, Eberhardt (2013), Eberhardt and Presbitero (2013) and Egert (2015b). The debt-value threshold ranges from 48,9% to 56,3% depending on the country. Table 4 reports the threshold model's results.

[15] However, for this country, the coefficient of the one year lagged value is statistically significant and positive.

Table 4: Specifications with threshold

Dependent variable: Real GDP per capita growth (in first-differences)

	Finland	Great Britain	Italy	The Netherlands
Real GDP per capita growth (-1)	-0.225	-0.413	-0.324	-0.633
	*0.046***	*0.005****	*0.001****	*0.000****
Real GDP per capita growth (-2)				-0.13
				0.246
Public debt ratio (if Public debt ratio ≤threshold)	-0.22	0.047	-0.859	-0.756
	*0.037***	*0.514*	*0.003****	*0.000****
Public debt ratio (if Public debt ratio>threshold)	-0.159	-0.642	0.585	0.71
	0.259	*0.000****	*0.026***	*0.002****
Public debt ratio(-1) (if Public debt ratio ≤threshold)	0.754	0.145	1.151	0.306
	*0.000****	*0.108*	*0.000****	*0.009****
Public debt ratio(-1) (if Public debt ratio>threshold)	-0.404	0.53	-0.727	-0.326
	*0.025***	*0.004****	*0.003****	*0.010***
Public debt ratio(-2) (if Public debt ratio ≤threshold)	-0.208			
	0.188			
Public debt ratio(-2) (if Public debt ratio>threshold)	0.105			
	0.52			
ECT(-1) (if Public debt ratio ≤threshold)				
ECT(-1) (if Public debt ratio>threshold)				
Government consumption	-2.545	-0.624	0.092	-1.925
	*0.000****	*0.18*	*0.868*	*0.000****
Gross fixed capital formation	0.062	0.719	0.807	0.439
	0.591	*0.014***	*0.077**	*0.038***
Openness to trade	10.967	-1.554	18.033	12.488
	*0.011***	*0.861*	*0.023***	*0.000****
GDP deflator	-0.407	-0.429	-0.466	-0.607
	*0.000****	*0.001****	*0.000****	*0.002****
School enrollment	0.001	0.177	0.119	0.082
	0.954	*0.023***	*0.637*	*0.001****
Population growth	-391.029	251.122	57.877	30.834
	0.219	*0.653*	*0.773*	*0.849*
Constant	0.231	-0.03	-0.745	-0.173
	0.267	*0.917*	*0.031***	*0.29*
Observations	41	39	38	37
R-squared	0.937	0.769	0.877	0.879

All the variables are in first-differences, except the error correction term (ECT)
p values in italics
*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

In most cases, the impact of public debt ratio's growth in one country is not the same in both regimes. The sign of its coefficient, its intensity and its significance vary. Regarding Great-Britain, public debt ratio has a statistically significant impact on economic growth only when its value is above 50,2%; the contemporaneous value of public debt ratio has a negative impact on GDP per capita growth but the one of the previous year is positive. In the other countries (Finland, Italy and the Netherlands), when public debt ratio is below its threshold, its impact is negative during the current year but becomes positive one year after. These effects are the opposite when the public debt ratio is above the threshold. Thus, when the public debt ratio's level is relatively low, public debt's benefits are first overcome by its burden and the positive effects are realized only one year after. When the public debt ratio is rather high, its effects on economic growth are positive during the current year (except in Finland where this effect is not statistically significant) but they become negative after one year.

Regarding the confidence interval of the threshold's value, the plots of the LR sequence against the estimated values of the threshold for these four countries are presented in figure D.1 in the Appendix. For each of these four countries, these graphics show that the estimated threshold's value lies in the "non rejection region". However, it can be observed that the confidence intervals are more accurate for Finland and The Netherlands than for Italy and Great Britain.

In short, the threshold model's results show that, in addition to be country specific, the relationship between public debt ratio and economic growth is not straightforward. It might be different according to the lag(s) of the public debt ratio variable and whether it is above or below its threshold. These two important results must be taken into account when establishing policies. Overall, the available evidence suggests that policy makers should be advised to consider that the link between public debt and economic growth as well as the eventual public debt ratio threshold are not universal but country-specific.

5. Discussion of the results

Our results' main conclusion is that the relationship between economic growth and public debt ratio vary among countries and that, for most of them, this link is linear (the debt-to-GDP threshold is statistically significant for only four countries out of 17). These two findings, which are confirmed by the ones of the robustness test section (see below), contradict mots papers on the debt-growth topic which state that not only the relationship between the two variables of interest is nonlinear but also that the debt-value threshold is common to all countries. Our conclusions are however also supported by several authors such as Bell et al. (2015) or Eberhardt and Presbitero (2015), for example.

The fact that the econometric specifications contain several lags of the public debt ratio variable makes it difficult to assess the sign of its impact on economic growth. In order to provide an estimate of this sign, it is possible, even if it is very rough, to sum up the public debt to GDP ratio variable's coefficients when they are statistically significant. Doing this exercise for the linear specifications tells us that public debt ratio's impact on economic growth is negative in about one third of the considered countries (i.e. in six countries: Belgium, Canada, Greece, Luxembourg, Portugal and Spain), positive in four countries (Denmark, France, Japan and the USA) and not statistically significant for the remaining three countries (Austria, Ireland and Sweden). Regarding the nonlinear specifications for Finland, Great Britain and Italy, the impact of public debt ratio on GDP per capita growth is positive in the lower regime and negative in the upper one. The opposite is observed in the Netherlands. Because of the crude way the sign of the impact of public debt ratio on economic growth is calculated, these conclusions must be interpreted with caution. They are summarized in table 5.

Table 5: Results' summary

	Linear model	**Threshold model**	
		lower regime	upper regime
ECM not validated	fra^{+}, jpn^{+}, usa^{+}	fin^{+}, ita^{+}	nld^{+}
	grc^{-}, prt^{-}	nld^{-}	fin^{-}, gbr^{-}, ita^{-}
	aut^{x}, irl^{x}, swe^{x}	gbr^{x}	-
ECM validated	dnk^{+}	-	-
	bel^{-}, can^{-}, lux^{-}, esp^{-}	-	-
	-	-	-

$^{+}$ the impact of public debt ratio on economic growth is positive
$^{-}$ the impact of public debt ratio on economic growth is negative
^{x} the impact of public debt ratio on economic growth is not statistically significant

Note: the sign of the impact is approximated by the sum of all statistically significant coefficients of the public debt to GDP ratio variable.

In the remaining part of this section, we further qualify our results by analyzing the impact of other growth determinants, presenting some robustness test's results and discussing the causality issue that might happen in the debt-growth relationship.

5.1 Other growth determinants

Regarding the other growth determinants that are also included in the econometric specifications, the results illustrated in tables 3 and 4 indicate that the lag(s) of GDP per capita growth has a stabilizing effect, as it exhibits a negative impact on its contemporaneous value for all countries, except for Canada and Spain, where it is non-significant. The remaining growth determinants' results show that their coefficients have the expected sign and that government consumption as well as inflation seem to be the most influent variables on GDP per capita growth besides public debt ratio and the lagged value(s) of GDP per capita growth. The impact of government consumption on economic growth is negative and statistically significant for all the countries of the sample but two (Portugal and Spain). As explained by Barro (1991 / p.430), government consumption has "no direct effect on private productivity but lowers saving and growth through the distorting effects from taxation or government-expenditure programs". Gross fixed capital formation's influence is positive. It shows that domestic investment increases the productivity of capital and can generate new jobs, which is beneficial for economic growth. However, this indicator is statistically significant only for Denmark and Spain. Regarding inflation, the results clearly indicate that it is harmful for the economy, confirming that a stable macroeconomic environment is important for economic growth. Openness to trade might increase the access to free markets, facilitate the transfer of technology and the diffusion of knowledge, and contribute to exploitation of comparative advantage. Thus this variable's impact on economic growth is positive. Regarding school enrollment ratio, it also has a positive impact on economic activity as education can bring, among others, higher income for individuals and also help to make investment more productive. This variable is statistically significant only for Portugal. Finally, population growth lowers income because the available capital must be spread over a larger population (see Mankiw et al. (1992)). However, as outlined by Headey and Hodge (2009 / p. 222), "the theoretical literature outlines both positive and negative effects of population growth"; for instance, a better educated working-age population growth might have positive effects on economic growth.

5.2 Robustness exercise

As robustness test, we perform the same analysis as in section 4.3 but this time we allow the coefficients of all the explanatory variables to vary across the two different regimes (see equations (7) and (8) above). Because of the low degree of freedom, it is important to note that these results must be taken with caution. They are reported in table D.5 in the Appendix and indicate that the threshold model is validated for only five countries (out of 17), which are Finland, Great Britain and Italy like in the basic set of specifications, and also Ireland and Spain. This implies that the relationship between public debt and GDP growth for the Netherlands is now linear (see table 3 above). Again, it can be concluded that the debt-value threshold is specific to each country; it ranges between 24,5% and 61,6%.

The results of the linear specification indicate that the contemporaneous value of public debt ratio has a negative impact on real GDP per capita growth in the Netherlands, which is also influenced by all the other growth determinants included in the specification, with the exception of population growth. The nonlinear estimations' results are reported in table D.6.in the Appendix and show that, in addition to be country-specific, the impact of public debt ratio on economic growth can also be different according to the regime and the lag(s) of the public debt ratio variable. Regarding Great Britain, the results are the same as the ones of the basic set of specifications. In Finland, public debt ratio has an impact on economic growth only in the upper regime suggesting that in this country, public debt ratio must be higher than 42,8% in order to have an influence on GDP per capita growth. In these two countries, the sign of the public debt ratio's variable changes according to its lags. In Spain, economic growth is influenced by the public debt ratio only in the lower regime and the link between these two variables is negative. Regarding Ireland and Italy, the results indicate that the public debt ratio has no influence on economic growth.

The plots of the LR sequence against the estimated values of the threshold for Finland, Great Britain, Ireland, Italy and Spain are illustrated in the figure D.2 in the Appendix. In each case, the graphics show that estimated threshold's value lies in the "non rejection region". It can be observed that the confidence intervals are more precise for Finland, Great Britain and Italy than for Ireland and Spain.

Contrary to the basic set of specifications, the other growth determinants don't always have the expected sign (in particular for Spain). Again, this must be taken with caution because of the lower reliability of the results due to the low degree of freedom. For this reason, the discussion of the counter-intuitive results is reported to Appendix B. Nevertheless, it seems that that the variable that have the most important influence on economic activity is openness to trade in the upper regime. Furthermore, it can all the same be concluded that the link between public debt ratio and economic growth is country-specific, which confirms the findings of the basic set of specifications and further supports the fact that considering one country's own characteristics is important for governments to implement well-shaped policy measures.

5.3 Causality issue

This paper analyzes the impact of public debt ratio on economic growth and its possible nonlinearity. However, according to economic theory, economic growth might also have an influence on public debt ratio. Indeed, a decrease of economic growth might induce higher public debt in order to allow the government to stimulate economic activity through increased spending (see for example, Dube (2013), Lof and Malinen (2014) and Gomez-Puig and Sosvilla-Rivero (2015)). This statement raises the issue of causality between the two variables of interest. In Appendix C, a short literature survey summarizes the results of recent papers dealing with causality between economic growth and the public debt ratio. It emphasizes the fact that there might be causality between these two variables and that it may vary among countries and the considered period of time. This implies that there might be endogeneity in our empirical application, which would yield to biased estimates because of feedback effects. However, this problem is not relevant in our study because ARDL modeling allows to deal with it. Indeed, Pesaran and Shin (1997 / p. 16) in particular explain that "appropriate modification of the orders of the ARDL model is sufficient to simultaneously correct for the residual serial correlation and the problem of endogenous regressors". Thus, despite the fact that we don't test for causality in this study and even if regressors in our econometric specifications might be endogenous, the ARDL methodology and, therefore, our results remain valid.

6. Summary

In this paper, the relationship between public debt GDP ratio and economic growth has been analyzed for 17 developed countries separately over the period 1970-2014. Several improvements have been provided in comparison with previous studies. In particular, we determined and tested for the debt-value threshold as well as analyzed the link between public debt and economic growth for each country individually. We also tested if the two variables of interest are cointegrated and we included additional growth determinants directly in the empirical setting. The results demonstrate that the relationship between public debt and growth as well as the debt-value threshold are country-specific. Indeed, they might depend on the institutional characteristics and the economic structure of the considered country, on the size of its public sector, on how and why public debt has been accumulated and/or on its composition. Several authors come to similar conclusions such as Rito Ribeiro et al. (2012) or Panizza and Presbitero (2013) for example.

Our empirical results offer an up-to-date confirmation of this heterogeneity across countries. They also illustrate which type of empirical issues need to be addressed to perform an in-depth analysis of the debt-growth relationship at the country level. The cointegration testing procedure showed that the ECM is validated for Belgium, Denmark, Finland, France, Greece, Ireland, Italy, Luxembourg, The Netherlands and Spain. The results indicate that the impact of public debt ratio on GDP growth might be positive, negative or null depending on the country and this variable's lagged values. Furthermore, the relationship between the two variables of interest is nonlinear for only four (out of 17) economies, which are Finland, Great Britain, Italy and the USA. Another result of this study is that the debt-value threshold also is country-specific, which further supports the fact that performing estimations for each country separately is crucial. This also implies that in different countries having a similar level of public debt, the impact of this variable on economic growth will not be necessarily the same in each country. Allowing the coefficients of all explanatory variables to vary across the two regime leads to similar conclusions.

In short, this study provides strong empirical support to the view that the relation between public debt and growth and the eventual debt threshold should be analyzed for each country individually. This has important policy implications; governments must take into account their own country's characteristics while designing fiscal policy measures aimed at, for example, stimulating growth or solving public debt problems. There is no universal recipe.

Although this paper has enlarged the number of country characteristics that deserve to be included in a thorough analysis, several possible improvements would be of interest in future work. The most important would be to use a methodology that would allow to simultaneously test long-run and short-run asymmetries. Longer time series would provide more accurate results and allow to test for an eventual second debt-to-GDP threshold's value and to estimate the same specifications for different sub-periods. The link between public debt and economic growth might also be clarified by taking into account different growth determinants, such as the quality of the institutions or the terms of trade for instance, as well as by considering various countries at different stages of development (not only industrialized economies). All these additional analyses should improve our understanding of the complex link between the public debt ratio and GDP per capita.

Appendix A: Data definitions

Exports of goods and services (current US$)

Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

GDP (current US$)

GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor calculated by the World Bank staff is used. In our sample, the countries for which there is a difference between the alternative conversion factor and the official exchange rate are the following: Austria, Belgium, Finland, France, Ireland, Italy, Luxembourg, Portugal, Spain and The Netherlands from 1970 to 1998 and Greece from 1970 to 2000. Sources: World Bank national accounts data, and OECD National Accounts data files.

GDP per capita (constant 2005 US$)

GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars. They exhibit the same growth rates as constant international U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

General government consolidated gross debt: Excessive deficit procedure (based on European System of Accounts (ESA) 2010) and former definition (linked series), percentage of GDP at market prices (excessive deficit procedure)

Government debt means the total gross debt at nominal value outstanding at the end of the year of the sector of general government, with the exception of those liabilities the corresponding financial assets of which are held by the sector of general government. Government debt is constituted by the liabilities of general government in the following categories:

Currency and deposits, securities other than shares, excluding financial derivatives and loans as defined in ESA 1995. The nominal value of a liability outstanding at the end of the year is the face value. The nominal value of an index-linked liability corresponds to its face value adjusted by the index-related change in the value of the principal accrued to the end of the year.

Liabilities denominated in a foreign currency, or exchanged from one foreign currency through contractual agreements to one or more other foreign currencies shall be converted into the other foreign currencies at the rate agreed on in those contracts and shall be converted into the national currency on the basis of the representative market exchange rate prevailing on the last working day of each year.

Liabilities denominated in the national currency and exchanged through contractual agreements to a foreign currency shall be converted into the foreign currency at the rate agreed on in those contracts and shall be converted into the national currency on the basis of the representative market exchange rate prevailing on the last working day of each year.

Liabilities denominated in a foreign currency and exchanged through contractual agreements to the national currency shall be converted into the national currency at the rate agreed on in those contracts.

Source: Eurostat (the Statistical Office of the European Commission).

General government final consumption expenditure (% of GDP)
General government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. Sources: World Bank national accounts data, and OECD National Accounts data files.

Gross fixed capital formation (% of GDP)
Gross fixed capital formation (formerly gross domestic fixed investment) is used as proxy for domestic investment. It includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are

also considered capital formation. Sources: World Bank national accounts data, and OECD National Accounts data files.

Imports of goods and services (current US$)
Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in current U.S. dollars. Sources: World Bank national accounts data, and OECD National Accounts data files.

Inflation, GDP deflator (annual %)
Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency. Sources: World Bank national accounts data, and OECD National Accounts data files.

School enrollment, secondary (% gross)
Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers. Sources: UNESCO Institute for Statistics.

Population growth (annual %)
Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of the country of origin. Sources: (1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

Appendix B: Robustness test's results discussion

According to the results presented in table D.6, the sign of the openness to trade's coefficient is not the same for each country. As explained in Kaplinsky et al. (2007), openness to trade's net effect is ambiguous as its impacts can be either positive (when trade is complementary) or negative (when more competition is created). Thus, some of the analyzed countries might have been more vulnerable than others to openness to trade, which would explain the negative sign of this variable's coefficient in Finland and in Spain in the upper regime. In Spain, when the public debt ratio is above its threshold value, the results show that the impact of government consumption is positive for economic growth. This might be the case, for example, when governments use public expenditure in an efficient way or in order to finance facilities that are not offered by the private economy, such as in the public health sector for example (see Musaba et al. (2013)). The results also indicate that gross fixed capital formation has a negative impact on economic growth in the lower regime in Spain and in the upper one in Great Britain, which is counterintuitive. However, according to the findings of Cheung et al. (2012), this might happen. These authors explain that, as countries become richer, the link between investment and growth weaken over time because of diminishing marginal returns to capital. In richer countries, marginal returns to investment might be close to zero or even negative, which might explain why, in some richer countries, investment might have a negative effect on growth. The negative impact of education on economic growth, which can be observed in Great Britain and in Spain in the upper regime, might be due to the fact that education is of low quality (see Pritchett (2001)) or because there is no appropriate match between the educational qualification and the current demand for labor (see Vijesandiran and Vinayagathasan (2015)).

Appendix C: Causality issue - short literature survey

Ferreira (2009) analyzes 20 OECD between 1988 and 2001 and finds that there is bi-directional Granger-causality between growth of real GDP per capita and public debt ratio. In order to study whether public debt has a causal effect on economic growth, Panizza and Presbitero (2014) consider 17 OECD countries over the 1981 to 2008 period. They use an instrumental variable approach and find that there is no evidence that public debt has a causal effect on economic growth. On the basis of the data used by Reinhart and Rogoff (2010a), and later Herndon et al. (2014), Bell et al. (2015) study the relationship between growth and debt in developed countries. Regarding causality, the authors developed a new method extending distributed lag models to multilevel situations. Their results, shown as impulse responses, suggest that the causal direction is predominantly from growth-to-debt, and is consistent (with some exceptions) across countries. Gomez-Puig and Sosvilla-Rivero (2015) performed

Granger-causality and endogenous breakpoint tests for 11 countries of the European Economic and Monetary Union separately over the 1980 to 2013 period. Their results show that causality between (changes in) public debt and economic growth vary among countries. By means of a panel bootstrap Granger-causality test and controlling for both the presence of cross-country heterogeneity and cross-sectional dependence, Puente-Ajovin and Sanso-Navarro (2015) analyze the possible causal relationship between debt and growth in 16 OECD countries from 1980 to 2009. The authors find that there is no Granger-causal effect of government debt on growth but that growth Granger-causes debt. Indeed, low economic growth leads to high levels of public debt. Ferreira (2016) uses panel Granger-causality estimations in order to study whether there is Granger-causality between real GDP growth and the growth of three debt categories: public, foreign and private debt. He considers 28 European Union countries over the 2001-2012 period. Regarding public debt, the author finds bidirectional causality between public debt and economic growth: economic growth Granger-causes a decrease in public debt and causality running from public debt to economic growth is positive.

Appendix D: Tables and Figures

Table D.1: Data summary

Austria

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	30129	7718	16780	41230
General government consolidated gross debt (percentage of GDP)	45	53.6	20.3	16.7	84.2
General government final consumption expenditure (% of GDP)	45	18.2	1.6	14.1	20.6
Gross fixed capital formation (percentage of GDP)	45	25.4	2.4	21.6	32.0
Openness to trade	45	0.8	0.2	0.5	1.1
Inflation, GDP deflator (annual %)	38	2.9	1.7	0.3	6.7
School enrollment, secondary (% gross)	43	97.4	5.3	88.8	107.0
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.88E+11	1.35E+11	1.53E+10	4.37E+11
Exports of goods and services (current US$)	45	8.23E+10	7.41E+10	4.21E+09	2.33E+11
Imports of goods and services (current US$)	45	7.93E+10	6.85E+10	4.22E+09	2.19E+11

Belgium

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	29130	6785	17257	38636
General government consolidated gross debt (percentage of GDP)	45	98.7	25.2	54.4	134.4
General government final consumption expenditure (% of GDP)	45	21.6	1.8	16.7	24.4
Gross fixed capital formation (percentage of GDP)	45	22.6	2.3	18.5	27.0
Openness to trade	45	1.2	0.2	0.8	1.7
Inflation, GDP deflator (annual %)	45	3.7	2.8	0.4	12.9
School enrollment, secondary (% gross)	43	111.2	25.3	80.8	163.1
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	2.35E+11	1.60E+11	2.68E+10	5.32E+11
Exports of goods and services (current US$)	45	1.62E+11	1.34E+11	1.19E+10	4.46E+11
Imports of goods and services (current US$)	45	1.57E+11	1.31E+11	1.14E+10	4.42E+11

Canada

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28898	5892	18798	38255
General government consolidated gross debt (percentage of GDP)	40	68.3	17.8	42.9	99.7
General government final consumption expenditure (% of GDP)	45	21.2	1.3	19.0	24.4
Gross fixed capital formation (percentage of GDP)	45	22.0	1.7	18.5	25.1
Openness to trade	45	0.6	0.1	0.4	0.8
Inflation, GDP deflator (annual %)	45	4.4	3.5	-2.1	15.2
School enrollment, secondary (% gross)	42	98.7	5.7	87.1	110.3
Population growth (annual %)	44	0.01	0.00	0.01	0.02
Nominal GDP (current US dollars)	45	6.98E+11	5.29E+11	8.78E+10	1.84E+12
Exports of goods and services (current US$)	45	2.24E+11	1.78E+11	1.93E+10	5.64E+11
Imports of goods and services (current US$)	45	2.17E+11	1.78E+11	1.70E+10	5.87E+11

Denmark

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	38559	8265	25145	50695
General government consolidated gross debt (percentage of GDP)	44	47.3	21.6	6.2	80.5
General government final consumption expenditure (% of GDP)	45	24.4	1.8	19.4	28.1
Gross fixed capital formation (percentage of GDP)	45	21.4	2.7	17.5	27.2
Openness to trade	45	0.7	0.1	0.5	1.0
Inflation, GDP deflator (annual %)	45	4.7	3.7	0.5	13.3
School enrollment, secondary (% gross)	43	111.7	11.7	93.0	131.0
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.55E+11	1.06E+11	1.69E+10	3.53E+11
Exports of goods and services (current US$)	45	6.84E+10	5.88E+10	4.61E+09	1.90E+11
Imports of goods and services (current US$)	45	6.16E+10	5.27E+10	5.10E+09	1.78E+11

Finland

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28836	8168	15787	42415
General government consolidated gross debt (percentage of GDP)	45	29.6	18.2	6.1	59.3
General government final consumption expenditure (% of GDP)	45	20.2	2.8	14.3	24.8
Gross fixed capital formation (percentage of GDP)	45	25.0	3.7	18.6	33.5
Openness to trade	45	0.6	0.1	0.4	0.9
Inflation, GDP deflator (annual %)	45	5.2	4.7	-0.1	22.1
School enrollment, secondary (% gross)	43	110.5	10.8	88.6	143.2
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.22E+11	8.45E+10	1.14E+10	2.84E+11
Exports of goods and services (current US$)	45	4.37E+10	3.64E+10	2.71E+09	1.28E+11
Imports of goods and services (current US$)	45	4.03E+10	3.46E+10	2.90E+09	1.18E+11

France

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28271	5886	17381	36074
General government consolidated gross debt (percentage of GDP)	38	51.3	22.3	20.1	95.6
General government final consumption expenditure (% of GDP)	45	21.7	1.9	16.9	24.2
Gross fixed capital formation (percentage of GDP)	45	22.5	1.8	19.4	26.8
Openness to trade	45	0.5	0.1	0.3	0.6
Inflation, GDP deflator (annual %)	45	4.5	4.0	0.1	13.8
School enrollment, secondary (% gross)	43	98.8	13.0	74.3	114.2
Population growth (annual %)	44	0.01	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.33E+12	8.72E+11	1.49E+11	2.92E+12
Exports of goods and services (current US$)	45	3.32E+11	2.50E+11	2.35E+10	8.12E+11
Imports of goods and services (current US$)	45	3.36E+11	2.66E+11	2.28E+10	8.69E+11

Great Britain

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	29704	8056	17781	41544
General government consolidated gross debt (percentage of GDP)	44	52.0	15.0	31.3	88.2
General government final consumption expenditure (% of GDP)	45	19.4	1.5	16.8	22.3
Gross fixed capital formation (percentage of GDP)	45	20.0	2.5	16.0	24.9
Openness to trade	45	0.5	0.1	0.4	0.6
Inflation, GDP deflator (annual %)	45	6.2	5.5	0.3	25.9
School enrollment, secondary (% gross)	42	91.0	9.6	76.6	105.4
Population growth (annual %)	42	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.26E+12	9.12E+11	1.31E+11	2.99E+12
Exports of goods and services (current US$)	45	3.33E+11	2.59E+11	2.79E+10	8.48E+11
Imports of goods and services (current US$)	45	3.54E+11	2.84E+11	2.67E+10	9.05E+11

Greece

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	17142	3429	10904	24470
General government consolidated gross debt (percentage of GDP)	45	76.8	47.7	15.9	178.6
General government final consumption expenditure (% of GDP)	45	17.6	2.7	11.1	23.3
Gross fixed capital formation (percentage of GDP)	45	24.0	5.2	11.6	35.4
Openness to trade	45	0.4	0.1	0.2	0.7
Inflation, GDP deflator (annual %)	43	10.7	8.3	-2.5	27.2
School enrollment, secondary (% gross)	41	89.3	10.4	63.3	108.2
Population growth (annual %)	42	0.00	0.00	-0.01	0.02
Nominal GDP (current US dollars)	45	1.29E+11	9.86E+10	1.31E+10	3.54E+11
Exports of goods and services (current US$)	45	2.67E+10	2.52E+10	1.04E+09	8.28E+10
Imports of goods and services (current US$)	45	3.76E+10	3.39E+10	2.00E+09	1.27E+11

Ireland

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	29915	15029	12041	53918
General government consolidated gross debt (percentage of GDP)	45	68.6	28.6	23.6	120.2
General government final consumption expenditure (% of GDP)	45	18.2	2.0	14.7	22.2
Gross fixed capital formation (percentage of GDP)	45	22.4	4.2	15.9	31.0
Openness to trade	45	1.3	0.4	0.7	2.1
Inflation, GDP deflator (annual %)	44	6.0	6.1	-4.3	21.0
School enrollment, secondary (% gross)	43	100.5	12.8	73.3	126.5
Population growth (annual %)	44	0.01	0.01	0.00	0.03
Nominal GDP (current US dollars)	45	9.19E+10	9.05E+10	4.40E+09	2.75E+11
Exports of goods and services (current US$)	45	7.87E+10	8.96E+10	1.45E+09	2.85E+11
Imports of goods and services (current US$)	45	6.78E+10	7.55E+10	1.82E+09	2.39E+11

Italy

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	25556	5527	15156	32831
General government consolidated gross debt (percentage of GDP)	45	87.9	27.3	35.7	132.3
General government final consumption expenditure (% of GDP)	45	18.2	1.4	15.1	20.6
Gross fixed capital formation (percentage of GDP)	45	21.7	2.5	16.6	26.8
Openness to trade	45	0.4	0.1	0.3	0.6
Inflation, GDP deflator (annual %)	45	7.4	6.2	0.3	20.8
School enrollment, secondary (% gross)	43	83.9	13.0	59.9	102.7
Population growth (annual %)	41	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	1.08E+12	7.17E+11	1.13E+11	2.39E+12
Exports of goods and services (current US$)	45	2.58E+11	2.00E+11	1.72E+10	6.45E+11
Imports of goods and services (current US$)	45	2.50E+11	1.99E+11	1.69E+10	6.64E+11

Japan

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	28642	7404	15162	37595
General government consolidated gross debt (percentage of GDP)	45	106.5	71.7	11.5	245.8
General government final consumption expenditure (% of GDP)	45	15.6	2.7	10.7	20.6
Gross fixed capital formation (percentage of GDP)	45	27.6	4.5	20.0	36.4
Openness to trade	45	0.2	0.1	0.2	0.4
Inflation, GDP deflator (annual %)	45	2.3	5.3	-2.2	22.7
School enrollment, secondary (% gross)	42	97.3	4.4	86.5	102.7
Population growth (annual %)	44	0.00	0.00	0.00	0.02
Nominal GDP (current US dollars)	45	3.06E+12	1.87E+12	2.09E+11	5.95E+12
Exports of goods and services (current US$)	45	3.84E+11	2.68E+11	2.21E+10	8.93E+11
Imports of goods and services (current US$)	45	3.58E+11	2.82E+11	1.96E+10	9.92E+11

Luxembourg

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	55052	20801	27550	87773
General government consolidated gross debt (percentage of GDP)	44	10.9	5.3	4.2	23.4
General government final consumption expenditure (% of GDP)	45	15.0	1.6	10.1	17.1
Gross fixed capital formation (percentage of GDP)	45	20.3	1.8	14.4	23.1
Openness to trade	44	2.3	0.7	1.5	3.7
Inflation, GDP deflator (annual %)	45	4.3	4.6	-1.9	21.3
School enrollment, secondary (% gross)	43	79.1	17.1	47.3	102.4
Population growth (annual %)	44	0.01	0.01	0.00	0.02
Nominal GDP (current US dollars)	45	2.09E+10	1.93E+10	1.52E+09	6.49E+10
Exports of goods and services (current US$)	45	3.25E+10	3.82E+10	1.37E+09	1.32E+11
Imports of goods and services (current US$)	45	2.70E+10	3.19E+10	1.02E+09	1.11E+11

Portugal

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	14285	3998	7487	19489
General government consolidated gross debt (percentage of GDP)	42	57.2	27.8	13.3	130.2
General government final consumption expenditure (% of GDP)	45	16.2	3.3	11.2	21.4
Gross fixed capital formation (percentage of GDP)	44	25.2	4.2	14.8	33.2
Openness to trade	45	0.6	0.1	0.4	0.8
Inflation, GDP deflator (annual %)	45	9.5	8.1	-0.4	26.4
School enrollment, secondary (% gross)	42	78.4	25.2	37.5	109.0
Population growth (annual %)	44	0.00	0.01	-0.01	0.04
Nominal GDP (current US dollars)	45	1.04E+11	8.25E+10	8.11E+09	2.62E+11
Exports of goods and services (current US$)	45	3.04E+10	2.80E+10	1.55E+09	9.21E+10
Imports of goods and services (current US$)	45	3.74E+10	3.20E+10	1.95E+09	1.07E+11

Spain

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	19809	5102	11541	27661
General government consolidated gross debt (percentage of GDP)	45	41.9	22.6	11.5	99.3
General government final consumption expenditure (% of GDP)	45	15.8	3.0	9.9	20.5
Gross fixed capital formation (percentage of GDP)	45	24.4	3.1	19.2	31.1
Openness to trade	45	0.4	0.1	0.3	0.6
Inflation, GDP deflator (annual %)	45	7.3	5.8	-0.4	23.4
School enrollment, secondary (% gross)	43	99.9	20.9	53.8	131.1
Population growth (annual %)	44	0.01	0.01	0.00	0.02
Nominal GDP (current US dollars)	45	6.09E+11	4.94E+11	4.09E+10	1.63E+12
Exports of goods and services (current US$)	45	1.49E+11	1.44E+11	4.98E+09	4.50E+11
Imports of goods and services (current US$)	45	1.60E+11	1.52E+11	5.58E+09	4.98E+11

Sweden

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	33686	7689	22806	46037
General government consolidated gross debt (percentage of GDP)	45	45.5	14.0	23.6	70.3
General government final consumption expenditure (% of GDP)	45	25.1	1.7	20.3	27.6
Gross fixed capital formation (percentage of GDP)	45	23.9	2.7	19.2	29.2
Openness to trade	45	0.7	0.1	0.4	0.9
Inflation, GDP deflator (annual %)	45	5.1	4.0	0.4	14.5
School enrollment, secondary (% gross)	43	103.9	24.2	76.9	156.6
Population growth (annual %)	44	0.00	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	2.50E+11	1.60E+11	3.76E+10	5.79E+11
Exports of goods and services (current US$)	45	9.97E+10	8.08E+10	8.49E+09	2.63E+11
Imports of goods and services (current US$)	45	8.83E+10	7.02E+10	8.45E+09	2.36E+11

The Netherlands

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	32829	7857	21061	45043
General government consolidated gross debt (percentage of GDP)	40	58.3	12.4	38.4	75.5
General government final consumption expenditure (% of GDP)	45	22.4	1.9	18.2	26.5
Gross fixed capital formation (percentage of GDP)	45	22.3	2.2	17.9	29.1
Openness to trade	45	1.1	0.2	0.8	1.5
Inflation, GDP deflator (annual %)	45	3.5	3.3	-1.0	13.2
School enrollment, secondary (% gross)	43	112.1	18.4	75.5	141.6
Population growth (annual %)	43	0.01	0.00	0.00	0.01
Nominal GDP (current US dollars)	45	3.92E+11	2.81E+11	3.77E+10	9.36E+11
Exports of goods and services (current US$)	45	2.54E+11	2.20E+11	1.64E+10	7.29E+11
Imports of goods and services (current US$)	45	2.26E+11	1.92E+11	1.64E+10	6.29E+11

USA

Variables	Nb of obs.	Mean	Std. Dev.	Min	Max
Real GDP per capita in (constant 2005) US dollars	45	34113	8232	21183	46405
General government consolidated gross debt (percentage of GDP)	45	61.0	18.1	40.2	104.8
General government final consumption expenditure (% of GDP)	45	15.8	1.0	14.0	18.1
Gross fixed capital formation (percentage of GDP)	45	21.6	1.6	18.0	24.4
Openness to trade	45	0.2	0.1	0.1	0.3
Inflation, GDP deflator (annual %)	45	3.6	2.4	0.8	9.3
School enrollment, secondary (% gross)	43	92.1	4.4	78.6	96.5
Population growth (annual %)	44	0.01	0.00	0.01	0.01
Nominal GDP (current US dollars)	45	7.60E+12	5.09E+12	1.08E+12	1.74E+13
Exports of goods and services (current US$)	45	8.09E+11	6.71E+11	5.97E+10	2.34E+12
Imports of goods and services (current US$)	45	1.03E+12	8.98E+11	5.58E+10	2.87E+12

Table D.2: Augmented Dickey-Fuller test

	Country							
Variable	**Austria**	**Belgium**	**Canada**	**Denmark**	**Finland**	**France**	**Great Britain**	**Greece**
Public debt ratio (% GDP)								
ADF statistic								
series in levels	-1.306	-2.864*	-3.210*,[a]	-2.481	-2.716	-2.643	0.241	-1.539
series in first-difference	-5.420***	-	-2.241**	-2.821***	-3.174***	-3.680***	-2.882***	-6.102***
constant $\neq 0$	Yes	Yes	No	No	No	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	1	3	0	0	3	0	0	0
Real GDP per capita growth								
ADF statistic								
series in levels	-5.729***,[a]	-6.679***,[a]	-4.710***	-5.386***,[a]	-3.773***	-5.294***,[a]	-4.710***	-3.798***
series in first-difference	-5.084***	-7.516***	-	-5.902***	-	-5.266***	-	-
constant $\neq 0$	No	No	Yes	No	Yes	No	Yes	No
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	4	1	0	4	0	4	1	0
General government final consumption expenditure (% of GDP)								
ADF statistic								
series in levels	-2.990	-2.807	-2.576	-2.494	-1.488	-3.495*,[a]	-2.929**	-1.713
series in first-difference	-4.548***	-5.204***	-4.985***	-5.515***	-5.306***	-4.607***	-	-7.307***
constant $\neq 0$	No	No	No	No	No	No	Yes	No
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	1	0	0	0	1	0	1	0
Gross fixed capital formation (% of GDP)								
ADF statistic								
series in levels	-4.297***,[a]	-2.253	-2.068	-2.541	-3.479*,[a]	-2.352	-4.688***,[a]	-2.297
series in first-difference	-6.743***	-4.907***	-5.304***	-4.297***	-3.755***	-4.171***	-4.382***	-5.581***
constant $\neq 0$	No	No	No	No	No	No	Yes	No
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	0	0	0	4	1	0	6	0
Population (total) growth								
ADF statistic								
series in levels	-4.217***,[a]	-0.933	-3.460*,[a]	-3.423*,[a]	-4.547***	-2.667*	2.091	-3.828**,[a]
series in first-difference	-3.990***	-6.787***	-6.523***	-1.982**	-	-	-3.874***	-5.051***
constant $\neq 0$	No	No	No	No	Yes	Yes	Yes	No
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	3	0	0	5	2	0	7	1
Openness to trade								
ADF statistic								
series in levels	-2.666	-3.161	-1.729	-2.363	-2.284	-3.02694	-2.350689	-3.139
series in first-difference	-5.609***	-6.221***	-4.569***	-5.113***	-6.441***	-5.791***	-6.894***	-5.578***
constant $\neq 0$	Yes	Yes	No	Yes	No	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	2	0	0	2	0	1	0	1
GDP deflator								
ADF statistic								
series in levels	-2.572197	-4.517***	-1.911*	-2.588**	-4.520***	-2.344	-2.371**	-2.219
series in first-difference	-4.243***	-	-	-	-	-4.920***	-	-9.285***
constant $\neq 0$	No	No	No	No	No	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	1	6	8	8	6	0	8	0
School enrollment, secondary (% gross)								
ADF statistic								
series in levels	-1.639463	0.643	-2.495011	-3.256*,[a]	-2.286684	-1.924577	-1.665	-2.641*
series in first-difference	-5.004***	-4.742***	-1.727*	-1.628*	-4.290***	-4.893***	-4.914***	-
constant $\neq 0$	No	No	No	No	No	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No
numer of lags (p)	0	0	0	1	0	0	0	0

Notes: The null hypothesis is that the series has an unit root.

p is the order of the augmentation needed to eliminate any autocorrelation in the residuals of the ADF regression.

*/ **/ *** indicate significance at 10%/ 5%/ 1% on the basis of the critical values by MacKinnon (1991).

[a]the series in levels is a trend stationary processus

Table D.2: Augmented Dickey-Fuller test (continued)

	Country								
Variable	**Ireland**	**Italy**	**Japan**	**Luxembourg**	**Portugal**	**Spain**	**Sweden**	**The Netherlands**	**United States**
Public debt ratio (% GDP)									
ADF statistic									
series in levels	-3.362**	-2.496	0.850	0.255	1.622	-4.343***,[a]	-2.532	-3.604**	-3.968**,[a]
series in first-difference	-	-3.688***	-3.693***	-2.934***	-3.472**	-2.792***	-2.982***	-	-2.727***
constant $\neq 0$	Yes	Yes	Yes	No	Yes	No	No	Yes	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	1	0	0	1	0	4	0	7	0
Real GDP per capita growth									
ADF statistic									
series in levels	-3.160**	-5.778***,[a]	-5.729***,[a]	-4.994***	-1.373	-2.316**	-4.851***	-2.891***	-4.799***
series in first-difference	-	-9.053***	-8.154***	-	-5.197***	-	-	-	-
constant $\neq 0$	Yes	No	No	Yes	No	No	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	0	1	1	0	6	0	0	0	0
General government final consumption expenditure (% of GDP)									
ADF statistic									
series in levels	-2.346	-2.353	-1.703	-2.990**	1.315	-2.674	-5.128***	-4.041	-2.772*
series in first-difference	-5.524***	-6.055***	-4.874***	-	-5.566***	-4.041***	-	-5.449***	-
constant $\neq 0$	No	No	Yes	Yes	No	Yes	Yes	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	1	0	0	0	0	2	6	0	1
Gross fixed capital formation (% of GDP)									
ADF statistic									
series in levels	-3.921***	-2.590	-3.160	-3.851***	-3.182	-2.741*	-2.523	-2.060	-3.796**,[a]
series in first-difference	-	-4.537***	-4.425***	-	-4.116***	-	-4.332***	-1.831*	-4.626***
constant $\neq 0$	Yes	No	No	Yes	No	Yes	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	9	0	1	0	2	1	0	7	2
Population (total) growth									
ADF statistic									
series in levels	-3.174**	-5.554***	-4.932***,[a]	-4.355***,[a]	-6.413***	-2.826*,[a]	-2.333	-2.247	-1.952
series in first-difference	-	-	-9.533***	-2.888*	-	-2.684***	-2.723***	-2.419**	-4.428***
constant $\neq 0$	Yes	No	Yes	Yes	No	No	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	9	9	1	9	4	5	2	9	2
Openness to trade									
ADF statistic									
series in levels	-2.833	-2.060	0.747	-1.520	-3.256*,[a]	-2.866	-2.580	-2.450	-3.385*,[a]
series in first-difference	-5.782***	-2.369**	-6.133***	-6.018***	-6.277***	-5.315***	-6.511***	-6.409***	-6.061***
constant $\neq 0$	Yes	No	No	Yes	No	No	No	No	Yes
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	0	8	0	0	0	0	0	0	1
GDP deflator									
ADF statistic									
series in levels	-3.703**,[a]	-2.468	-2.732***	-8.437***,[a]	-3.024	-2.696	-3.443*,[a]	-3.015***	-2.004**
series in first-difference	-8.153***	-6.306***	-	-5.846***	-2.172**	-5.981***	-7.480***		-
constant $\neq 0$	No	Yes	No	No	No	No	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	0	3	6	4	5	0	0	0	7
School enrollment, secondary (% gross)									
ADF statistic									
series in levels	-3.058	-3.303*,[a]	-2.995**	-4.360***,[a]	1.193	-2.918	-4.386***,[a]	-1.818	-1.836
series in first-difference	-4.270***	-4.353***	-	-5.060***	-4.192***	-4.500***	-4.491***	-4.960***	-3.924***
constant $\neq 0$	Yes	Yes	Yes	Yes	No	Yes	No	No	No
trend $\neq 0$	No	No	No	No	No	No	No	No	No
numer of lags (p)	4	0	0	0	0	1	0	0	2

Notes: The null hypothesis is that the series has an unit root.

p is the order of the augmentation needed to eliminate any autocorrelation in the residuals of the ADF regression.

*/ **/ *** indicate significance at 10%/ 5%/ 1% on the basis of the critical values by MacKinnon (1991).

[a]the series in levels is a trend stationary processus

Table D.3: Optimal number of lags, Breusch-Godfrey serial correlation LM test and ARDL bounds test

	Optimal number of lags		**Breusch-Godfrey serial correlation LM test**[1]		**ARDL bounds test**[2]
Country	Real GDP per capita growth	Public debt ratio (% GDP)	F-stat	Prob	F-statistic
Austria	1	0	0.622565	0.6101	9.809349***
Belgium	1	0	1.389372	0.2736	8.065755***
Canada	1	0	1.868461	0.1732	7.087152***
Denmark	1	1	2.237459	0.1153	20.20461***
Finland	1	2	1.082378	0.3804	18.57559***
France	1	1	1.950517	0.1766	20.58465***
Great Britain	1	1	1.316591	0.2998	18.81013***
Greece	1	2	0.665753	0.5860	4.851426**
Ireland[3]	4	2	1.427348	0.2797	3.330997
Italy	1	1	1.9827	0.1548	36.87924***
Japan	2	0	0.468061	0.7084	37.55937***
Luxembourg	2	1	1.478318	0.2540	8.430628***
Portugal	1	1	1.4035	0.2761	8.831281***
Spain	1	0	0.649825	0.5918	6.857118***
Sweden	2	0	2.29873	0.1101	16.91255***
The Netherlands	2	1	1.595988	0.2321	7.403496***
United States	1	0	2.308088	0.1059	28.22112***

[1] H_0: there is no serial correlation up to lag order p, where p is a pre-specified integer (here: p=3)

[2] H_0: no long-run relationships exists / Exact critical values by Narayan (2005) (here: k=7, where k+1 is the number of variables)

***, ** and * indicate that H_0 is rejected at the 1%, 5% and 10% significance level respectively

[3] for Ireland, we let the number of lags be up to 4. Otherwise, it is not possible to get a specification with no serial error correlation and which is stable.

Table D.4: Stability test

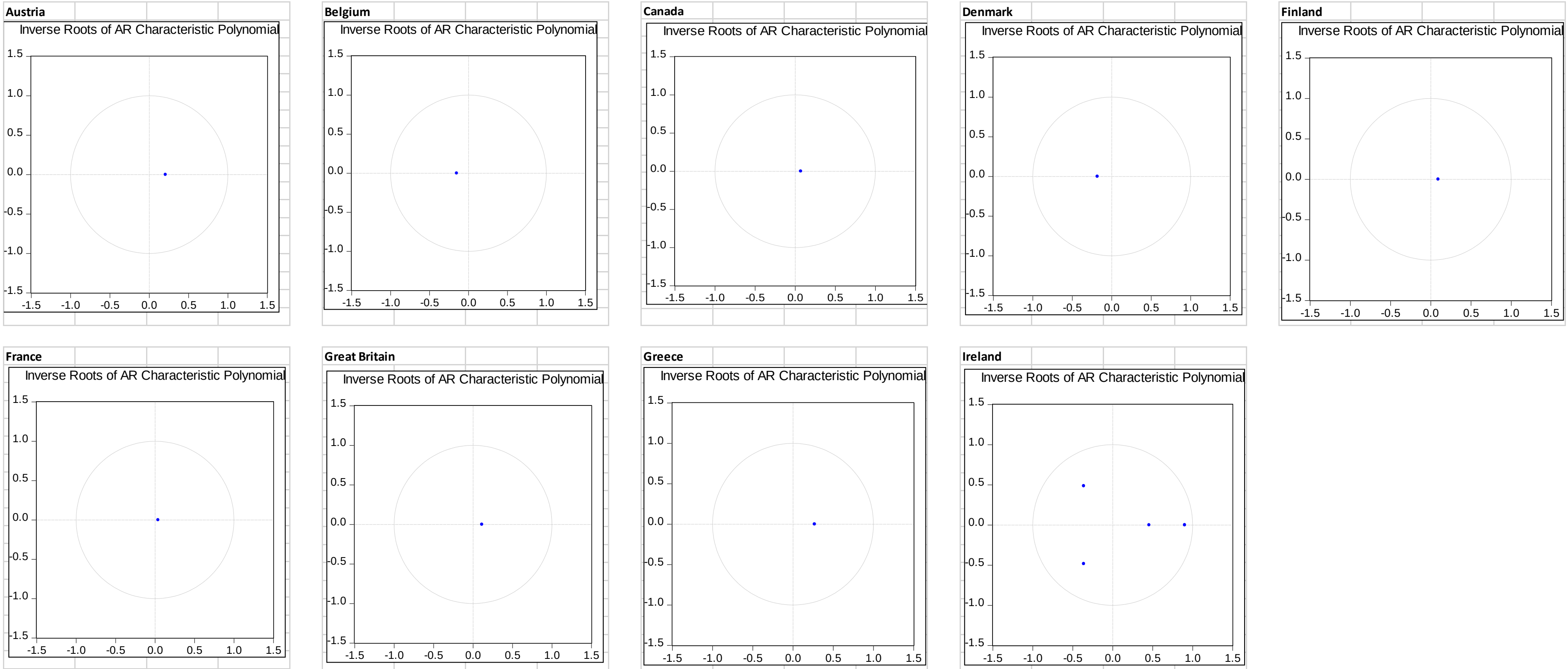


Table D.4: Stability test (continued)

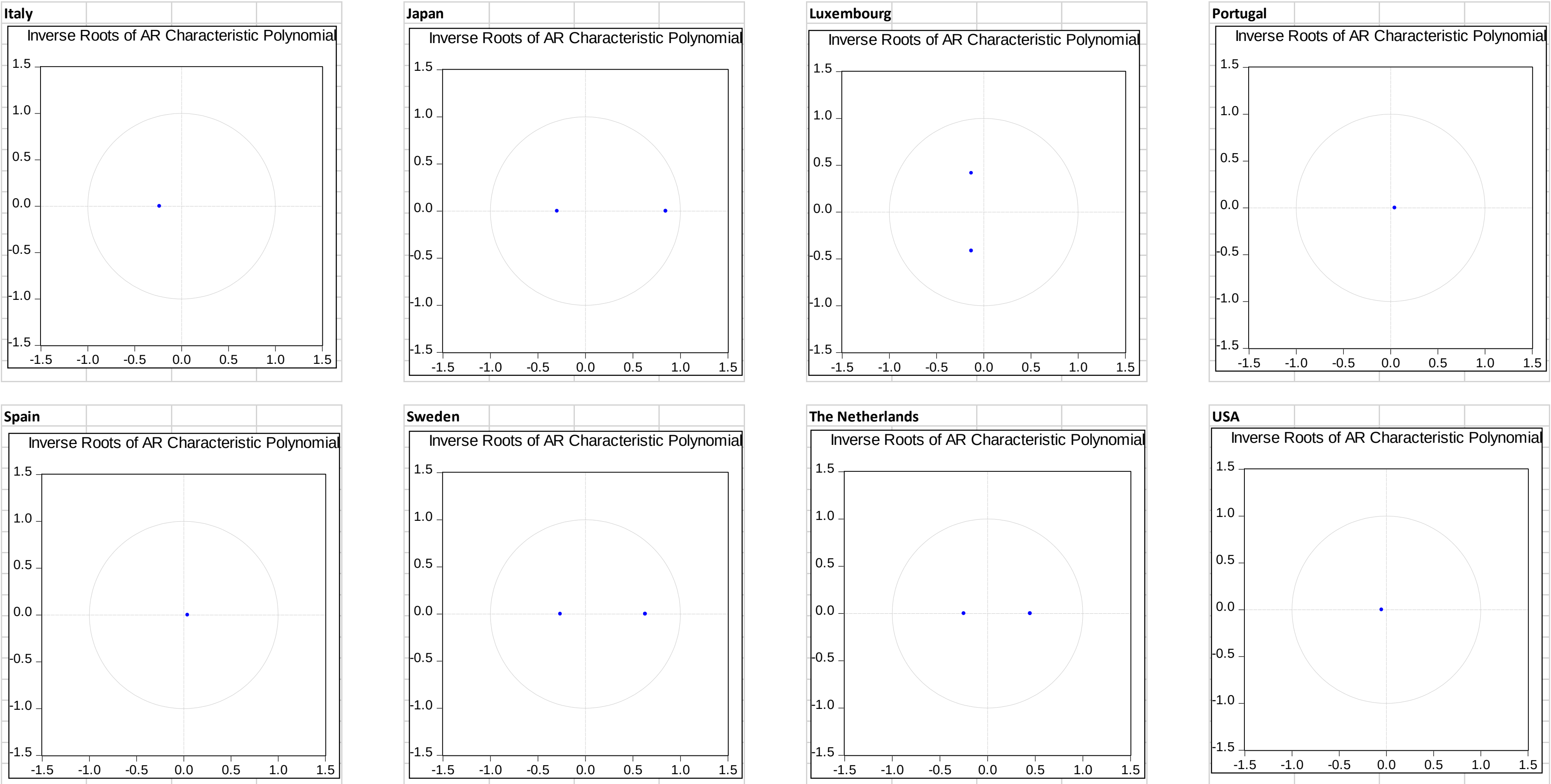


Table D.5: Threshold that minimizes SSR, F statistic and bootstrap p-value

Countries	**Threshold of public debt ratio (% GDP) that minimizes SSR**	**F Statistic**	**Bootstrap p-value**[1]
Austria	47.9	42.2	0.533
Belgium	94.6	38.3	0.397
Canada	74.7	32.0	0.369
Denmark	61.8	26.5	0.616
Finland	**42.8**	**104.9**	**0.033**
France	61.1	36.3	0.353
Great Britain	**51.2**	**87.5**	**0.044**
Greece	48.8	46.6	0.722
Ireland	**61.6**	**220.0**	**0.038**
Italy	**57.2**	**108.2**	**0.024**
Japan	169.6	54.2	0.141
Luxembourg	6.4	41.4	0.713
Portugal	56.0	52.4	0.258
Spain	**24.5**	**84.6**	**0.077**
Sweden	39.8	28.4	0.826
The Netherlands	51.4	67.9	0.144
USA	53.0	33.7	0.710

[1] Generated on the basis of Hansen's (1996) procedure

Table D.6: Specifications with threshold

Dependent variable: Real GDP per capita growth (in first-differences)

	Finland	Great Britain	Ireland	Italy	Spain
Real GDP per capita growth (-1) (if Public debt ratio ≤threshold)	-0.132	0.007	2.222	-0.503	-0.006
	0.379	*0.974*	*0.252*	*0.119*	*0.948*
Real GDP per capita growth (-1) (if Public debt ratio>threshold)	-2.947	-1.177	-3.021	0.326	0.013
	*0.000****	*0.000****	*0.131*	*0.353*	*0.921*
Real GDP per capita growth (-2) (if Public debt ratio ≤threshold)			1.241		
			0.121		
Real GDP per capita growth (-2) (if Public debt ratio>threshold)			-2.253		
			*0.013***		
Real GDP per capita growth (-3) (if Public debt ratio ≤threshold)			-2.425		
			0.332		
Real GDP per capita growth (-3) (if Public debt ratio>threshold)			1.934		
			0.436		
Real GDP per capita growth (-4) (if Public debt ratio ≤threshold)			-2.755		
			0.239		
Real GDP per capita growth (-4) (if Public debt ratio>threshold)			2.315		
			0.318		
Public debt ratio (if Public debt ratio ≤threshold)	-0.075	0.076	0.951	-1.331	-0.56
	0.616	*0.482*	*0.383*	*0.159*	*0.009****
Public debt ratio (if Public debt ratio>threshold)	18.101	-0.645	-1.058	0.767	0.313
	*0.000****	*0.000****	*0.335*	*0.392*	*0.135*
Public debt ratio(-1) (if Public debt ratio ≤threshold)	0.441	0.078	-0.195	1.436	
	0.109	*0.53*	*0.695*	*0.227*	
Public debt ratio(-1) (if Public debt ratio>threshold)	-3.526	0.321	0.191	-0.974	
	*0.000****	*0.019***	*0.707*	*0.425*	
Public debt ratio(-2) (if Public debt ratio ≤threshold)	-0.075		-1.022		
	0.661		*0.16*		
Public debt ratio(-2) (if Public debt ratio>threshold)	3.107		1.159		
	*0.000****		*0.118*		
ECT(-1) (if Public debt ratio ≤threshold)					-0.976
					*0.002****
ECT(-1) (if Public debt ratio>threshold)					0.234
					0.447
Government consumption (if Public debt ratio ≤threshold)	-2.977	-0.74	-17.163	0.063	-10.626
	*0.000****	*0.292*	*0.252*	*0.976*	*0.010****
Government consumption (if Public debt ratio>threshold)	-110.892	-1.176	16.489	1.099	9.948
	*0.000****	*0.108*	*0.27*	*0.647*	*0.015***
Gross fixed capital formation (if Public debt ratio ≤threshold)	0.031	0.407	*-2.342*	6.353	-2.093
	0.798	*0.319*	0.411	*0.236*	*0.070**
Gross fixed capital formation (if Public debt ratio>threshold)	48.977	-1.548	2.959	-6.849	2.691
	*0.000****	*0.003****	*0.305*	*0.208*	*0.024***
Openness to trade (if Public debt ratio ≤threshold)	9.499	3.823	-58.625	-29.097	169.337
	*0.072**	*0.795*	*0.303*	*0.329*	*0.012***
Openness to trade (if Public debt ratio>threshold)	-1.179	48.748	61.348	55.938	-167.842
	*0.000****	*0.004****	*0.285*	*0.081**	*0.013***
GDP deflator (if Public debt ratio ≤threshold)	-0.468	-0.425	0.096	-1.820	-0.233
	*0.000****	*0.065**	*0.922*	*0.031***	*0.145*
GDP deflator (if Public debt ratio>threshold)	-7.677	0.089	-0.268	1.185	-0.084
	*0.000****	*0.689*	*0.785*	*0.157*	*0.674*
School enrollment (if Public debt ratio ≤threshold)	-0.024	0.068	-1.123	2.147	0.686
	0.567	*0.437*	*0.38*	*0.115*	*0.033***
School enrollment (if Public debt rati>threshold)	1.659	-0.353	0.530	-1.915	-0.699
	*0.000****	*0.001****	*0.677*	*0.127*	*0.031***
Population growth (if Public debt ratio ≤threshold)	-494.077	-93.519	-821.043	0.000	419.046
	0.134	*0.917*	*0.367*	*1*	*0.203*
Population growth (if Public debt ratio>threshold)	96.969	484.72	1089.986	-248.498	-637.302
	*0.000****	*0.602*	*0.244*	*0.97*	*0.065**
Constant (if Public debt ratio≤threshold)	0.435	0.047	3.354	-1.105	
	0.129	*0.929*	*0.519*	*0.877*	
Constant (if Public debt ratio>threshold)	-6.281	-0.43	-2.103	0.520	
	*0.000****	*0.44*	*0.685*	*0.94*	
Observations	41	39	38	38	41
R-squared	*0.959*	*0.889*	0.958	*0.943*	*0.941*

All the variables are in first-differences, except the error correction term (ECT)

p values in italics

*, ** and ***: statistical significance at the 10, 5 and 1 percent level respectively.

Figure D.1: Likelihood ratio test for the threshold (original specification)

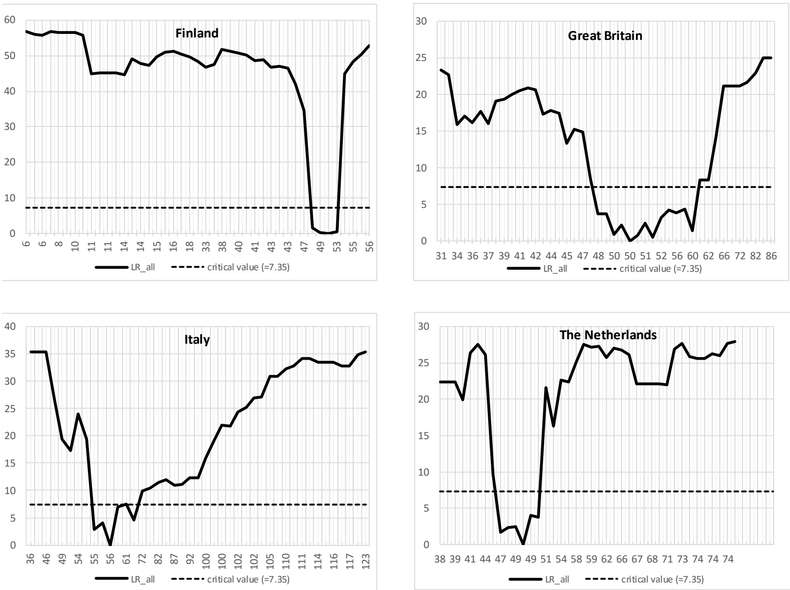
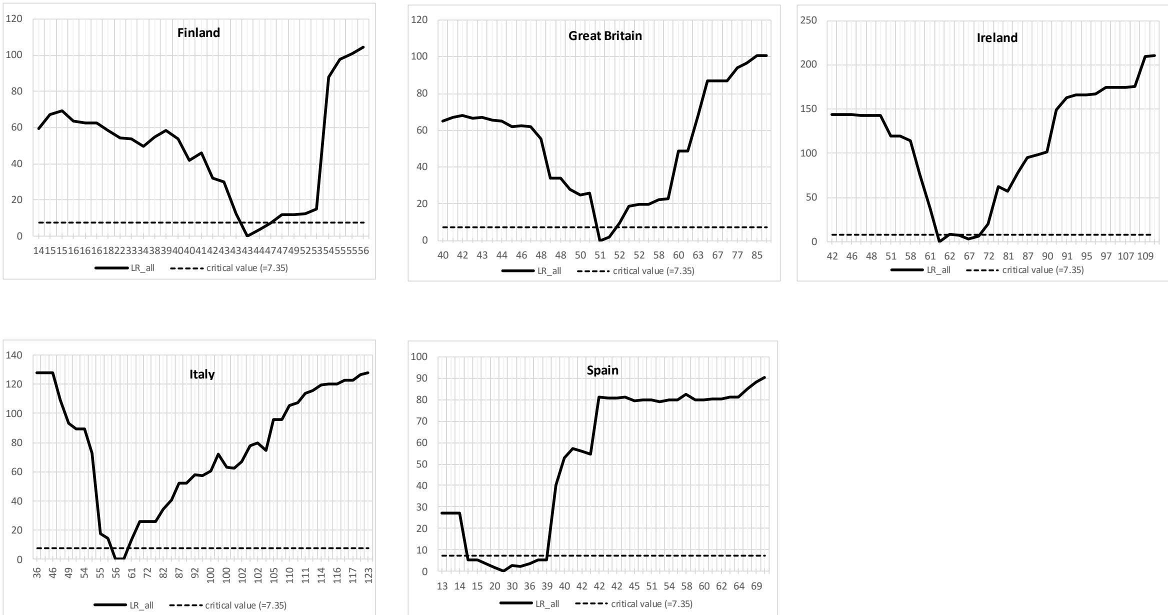


Figure D.2: Likelihood ratio test for the threshold (robustness specification)



General Conclusion

> "Despite its enormous importance, the determinants of the growth rate of a country remain one of economics' biggest mysteries. There is no magic solution to the problem of economic growth. The process of economic growth is rather complex and many factors are needed if a country is to succeed."
>
> Sala-i-Martin et al. (2003)

1. Main Findings

This thesis investigates empirically three growth-related topics: the impact of foreign direct investment on economic growth, the impact of trade with China on African economic growth and the relationship between public debt and economic growth. Even if these three themes are distinct, the results help to better understand the economic growth process and provide some hints on how to promote and sustain it.

The analysis of causality between FDI and growth presented in Chapter 1 demonstrates that host country social and economic conditions might have an impact on GDP per capita and on FDI inflows. It also reveals that, contrary to what is commonly assumed, the optimal lag-length is not identical for each explanatory variables. This has important implications, as results from causality tests are highly sensitive to the order of lags in the autoregressive process. Regarding causality, in the basic specification, no Granger-causality can be observed between FDI and economic growth. However, if we correct for cyclical disturbances by averaging series over several years, new and significant results emerge: FDI positively Granger-causes economic growth and there is no reverse causality. Moreover, host country local conditions do play a role for the two variables of interest.

Chapter 2 highlights the fact that trade with China has had a positive global influence on African economic growth but only since the beginning of this century and that, during this period, trade with China has had more influence on African economic growth than trade with the EU did. In general, the impact of the openness to trade variables is different according to the kind of commodities which are traded, the trading partners which are involved and the period of time which is considered.

In the last chapter, the debt-growth relationship is analyzed at the country level and the results emphasize again the importance of country specificity. Indeed, results regarding cointegration, nonlinearity, the value of the debt threshold and the impact of public debt on economic growth are different among the considered countries. This implies, among other things, that in a group of countries sharing a similar level of public debt, the impact of this variable on economic growth may well be different from one country to the other.

2. Policy Implications

This thesis's results lead to two general policy implications. The first one is that all three growth determinants under investigation, i.e. trade, FDI and debt level appear to have a significant impact on growth performance for the majority of the considered countries. This result is important in a world that remains highly globalized and interdependent in the aftermaths of the great recession, but with a progressive redistribution of economic power among the major players and with most large countries being highly indebted. In spite of protectionist pressures, these trends are susceptible to be long lasting, making relevant the issues covered by the present thesis. However, that trade, FDI and debt turn out to be important growth determinants falls short of providing governments with enough guidelines on how to design the most appropriate growth-promoting policies.

The second general result is that including country specific characteristics is critical in order to shape effective growth promoting policies. This is in line with recent advances in the literature. As stated by Moral-Benito (2012), "theory does not provide enough guidance to select the proper empirical model. Country-specific effects correlated with other regressors play an important role". This implies that a given set of measures aiming at generating growth can be a success in one country and does not work at all in another one. Many results obtained in this thesis confirm this viewpoint, which calls to control for country-specific effects (first two chapters) or to perform country-level analysis (last chapter). Moreover, as illustrated by chapter 2, where China outperforms the EU in its influence on African growth in the recent decade, relationships are not necessarily stable over time.

In short, the appropriate measures aiming at improving economic growth vary among countries and over time. This is a tall order for policy makers who seek to identify and strengthen the factors that will enable future economic growth. It makes it particularly relevant to pursue and enrich the empirical agenda, as argued in the next section.

3. General limitations and further research

The three analyses have several limitations that have been mentioned in the conclusions of each chapter. Several general improvements, which are common to the three studies, are summarized below.

A first strategy would be to take advantage of the increased availability of larger databases, enriching the scope of empirical specifications. The three analysis could be clarified by taking into account more disaggregated data, or by including more growth determinants and taking interactions between them into account. This would also allow detecting possible substitution or complementarity effects between alternative growth-enhancing policies. Increasing the number of observations over time could improve the precision of the results. The use of times series or of panel data models that allow heterogeneous coefficients could make possible to perform the analyses of Chapters 1 and 2 for each country separately. The second type of models could allow performing additional robustness tests in Chapter 3. Enlarging the dataset in such a way would also allow making the same analysis for more detailed subgroups of countries, different sub-periods, or different stages of development.

A second strategy would be to rely on recent efforts to improve data quality. Taking trade data as an example, it is important to correct for asymmetries between imports (recorded by country of origin) and exports (reported by country of last known destination). Worldwide databases on bilateral trade flows make it possible to correct for these asymmetries providing mirror export data (e.g. OECD (2017)). Another important issue regarding trade data is that reported gross trade flows are inflated for products that cross borders several times along the value chain, which is increasingly the case. The concept of trade in value added (e.g. Escaith (2013)), which applies the principles of input/output analysis at the worldwide level, allows avoiding this double counting and identifying the precise contribution of each country in the value of the final imported good. The corresponding WTO-OECD project has now made these estimates available for a selection of countries and the recent period, along with better quality data on balanced bilateral trade in services (see Fortanier et al (2017)).

A third strategy would be to enlarge the scope of the analysis with alternative methodologies. Recent research on structural transformation seems a promising avenue. Analyzing structural change in one country consists in analyzing the flow of resources from the traditional sector to the modern one. The critical process from this viewpoint is the reallocation of resources from low to high-productivity sectors, which leads to higher economic growth. As explained by Rodrik et al. (2017 / p. 3), "economywide growth depends largely on the rate at which resources - principally labor - can migrate from the traditional to the modern sector". This type of analysis is complementary to the ones performed in this thesis, which are based on neoclassical growth models. It aims to help governments and policy-makers to better understand their economies by identifying the channels of structural change.

All the additional developments suggested above are already under way. They should improve our understanding of the complex relationships sustaining economic growth.

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