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GROWTH, DEFICITS AND UNCERTAINTY: THEORETICAL ASPECTS AND EMPIRICAL EVIDENCE

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Growth, Deficits and Uncertainty:
Theoretical Aspects and Empirical Evidence

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Abstract

We examine the relationship between fiscal deficits and per-capita income growth in a panel of 27 European countries, allowing for perceived risks, in terms of fiscal sustainability, associated with additional government spending. Such risks are proxied by the conditional variability of manufacturing production and stock market returns and by the unconditional variability of two survey-based economic-sentiment indicators. To help clarifying how fiscal variables impact on growth and to provide a point of reference for the interpretation of the empirical results a structural growth model is first identified. We find evidence of an asymmetric relationship, in that fiscal deficits give rise to adverse growth effects if they coincide with high uncertainty regarding the prospects of the economy and no significant negative growth effects in the low-uncertainty case.

Key words: growth, fiscal policy, government budget constraint, uncertainty
JEL Classification: O40, E60, H60, D80

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I. Introduction

The relationship between fiscal policy and long-run macroeconomic performance has been a subject of long-standing debate and controversy, both among policymakers and in academic circles. Recently, and particularly after the global financial crisis of 2007-2009, this debate has been intensified as many countries have set constraints on public expenditures, either as part of area agreements, such as the Stability & Growth Pact in Europe, or in an attempt to avoid rising interest rates on public debt and speculative attacks on their currencies. In the Eurozone alone, public expenditures have been reduced by 17% between 1995 and 2011. At the same time, public debt has remained at relatively high levels, ranging from 73% in the Eurozone countries to 68% in the US and 164% in Japan. In view of these developments, how fiscal expansions impact on economic growth becomes crucial. The conventional view in the theoretical literature is that debt-financed fiscal expansions adversely affect growth by introducing distortions in product and financial markets and by crowding out private investment. A number of analytical studies, however, stress that government purchases, financed either by new debt issues or by taxes, can be growth-enhancing by having the potential to increase the resource base of the economy and the productivity of all private input factors.[1] The empirical evidence is equally inconclusive, with some authors reporting results that suggest a strong negative relationship between fiscal variables and growth, while others fail to identify any statistically significant negative link or find evidence of a positive association.

Much of the existing empirical literature is not based on explicit structural modelling. Lack of structural modelling, however, implies lack of insights into how to specify the empirical model and how to interpret the estimation results. Crucial in this respect are the implications of the government budget constraint, which many existing empirical studies often neglect, despite the fact that the impact of higher public expenditures on growth cannot be examined independently of their financing. Indeed, to examine the relationship between fiscal policy and growth, one needs an indicator of the extent to which any existing current fiscal imbalances are perceived by the markets to be associated with higher future risks. This can be expected to be related to the degree of uncertainty regarding the prospects of the economy. If uncertainty is above a certain threshold, a current fiscal deficit is likely to reflect an excessive public-sector position, thus leading to lower investment and growth in the longer run. If, on the other hand, low uncertainty prevails, even a relatively large current deficit can be expected to reflect either increases in government expenditures that pay off in the future, through resource-enhancing effects, or short-run fiscal adjustment to exogenous shocks that subsequently reverse themselves. Accordingly, in such cases, current fiscal deficits are less likely to be seen by the markets as phenomena that entail potential dangers in subsequent years, in which case they will have no adverse impact on growth.

The objective of this paper is to explore how uncertainty regarding the prospects of the economy influences the relationship between fiscal deficits and per-capita income growth. To this end, we first identify a structural growth model which takes explicit account of the government budget constraint and which serves as a guide for the empirical specification and a point of reference for the interpretation of

[1] See Zagler & Dürnecker (2003), Romp & de Haan (2007) and Bayraktar & Moreno-Dodson (2010) for a survey.

our results. Then, we construct four alternative measures of economic uncertainty, which differ both in terms of the methodology we employ to derive them and in terms of the forward-looking elements they contain, and examine their interactions with fiscal deficits, after controlling for other conventional determinants of growth. We focus on a panel of 27 European countries.[2]

Our results provide evidence for the existence of an asymmetry in the way fiscal imbalances affect per-capita income growth. Regardless of the measure of uncertainty used, we find that fiscal deficits have a strong adverse impact on growth in cases of high uncertainty but no significant negative effect in cases of low uncertainty. This has important policy implications. It suggests that information regarding the prospects of the economy is crucial in any assessment of the growth-fiscal deficit relationship.

The rest of the paper is organized as follows. Section II discusses the existing literature. Section IIIa presents the structural model and Section IIIb describes the empirical specification. Section IV describes the methodology used to derive the uncertainty measures and reports the estimation results. Section V contains concluding comments.

II. Literature overview

The relationship between fiscal policy and economic growth is a subject of long-standing controversy and debate in macroeconomics. The debate is not so much focused on taxes per se, as the bulk of the theoretical and empirical literature suggests that exogenous (discretionary) increases in tax rates, as opposed to induced tax increases resulting endogenously from other developments in the economy, including the need to finance resource-enhancing government purchases, are growth reducing (Myles (2009); Romer & Romer (2010); Barro & Redlick (2011)).[3, 4] Instead, it is the growth impact of deficit-financed increases in public expenditures that has attracted most attention in the literature. Much of the theoretical literature stresses that deficit-financed government purchases lower growth by introducing distortions in product and financial markets and by crowding out private investment. Other analytical studies, however, along the lines suggested by Aschauer (1989) and Barro (1990), emphasize that fiscal deficits are not necessarily bad for growth, as, holding taxes constant, higher public spending has the potential to raise the productive capacity of the economy by improving the quality, and/or increase the total supply, of all input factors.

The empirical evidence is mixed, with some studies providing support for the hypothesis of a strong adverse effect of higher fiscal deficits on growth, while other studies fail to identify any robustly negative

[2] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom. The country sample follows from data availability for all variables, including the uncertainty measures, and the objective to have economies with different per-capita income levels but not very dissimilar institutional characteristics.

[3] Growth-reducing effects from higher average tax rates (i.e. government revenue as per cent of GDP), holding fixed other fiscal variables (i.e. government expenditures or fiscal deficits), are also reported in Bleaney *et al.* (2001), Afonso & Furceri (2010), Alesina & Ardagna (2010) and Gemmell *et al.* (2011).

[4] Other studies emphasize the importance of distinguishing between substitution effects, resulting from changes in marginal (effective) tax rates, which influence decisions about work vs. leisure and human/physical capital accumulation, and wealth effects resulting from changes in average tax rates. Although effective marginal-income tax rates are not directly observable and measuring them is not always easy, the existing empirical evidence points overwhelmingly to the conclusion of strong negative growth effects from higher marginal tax rates (Padovano & Galli (2001); Barro & Redlick (2011); Lee & Gordon (2005); Arnold *et al.* (2011)).

effect or report evidence of a positive impact. Easterly & Rebelo (1993), for example, who were among the first to examine empirically the link between fiscal variables and per-capita income growth, found strong evidence of adverse growth effects of fiscal deficits, using 5-year-period average growth data from a large number of countries since 1960. Bleaney *et al.* (2001) have confirmed this result by reporting growth-reducing effects of deficits for a panel of OECD countries for 1970-1995, after addressing a number of econometric issues, including the potential endogeneity of the fiscal variables used in the growth regressions. Gupta *et al.* (2005), using data from developing countries, also report estimates implying that deficits are growth-reducing, while Romero-Avila & Strauch (2008), controlling for both sides of the government budget, present results showing negative responses of GDP growth to fiscal variables in general in a panel of EU countries for 1990-2005. Alesina & Ardagna (2010) reach a similar conclusion indirectly, by addressing the issue of whether tax cuts or spending increases are more expansionary. Employing an 'event' approach to identify major fiscal-policy changes in 21 OECD countries since 1970, they present evidence indicating that fiscal deficits are strongly growth-reducing while tax cuts are more expansionary than increases in government purchases.

Other studies have reached different conclusions, criticising existing findings in a number of directions. Levine & Renelt (1992), for example, based on a broad country sample for 1960-1985, have questioned the robustness of earlier results by showing their sensitivity to small variations in the set of regressors, with their findings indicating no general evidence that fiscal deficits are growth-reducing. Hsieh & Lai (1996) have been unable to establish clear evidence that deficit-financed spending slows down growth using historical data from the G7 countries and vector-autoregression analysis, while Miller & Russek (1997) have failed to identify any significant negative link between higher debt-financed expenditures and growth in the advanced economies using both fixed- and random-effects panel estimation. Barro & Redlick (2011) present similar results, suggesting that budget deficits are not necessarily harmful for growth, by reporting positive growth multipliers for the US during 1950-2006 both for defence and non-defence government purchases, holding fixed changes in taxes. At the same time, Baldacci *et al.* (2004) and Adam & Bevan (2005) have found non-linear effects on growth from fiscal policy, with their estimates, from panels of 45 developing countries and 39 low-income countries respectively, indicating that fiscal deficits below a certain threshold can be growth-enhancing. Lin (2000), Futagami *et.al.* (2008) and Minea & Villieu (2009), based on analytical endogenous-growth models, also find non-linearities in the way fiscal deficits affect per-capita growth rates, showing that higher public deficits and government debt do not necessarily reduce growth. Reinhart & Rogoff (2010) confirm the existence of non-linearities, as historical annual data for 44 countries covering a period of almost two centuries show no significant negative link between growth and debt levels for debt-to -GDP ratios less than 90%.

Analogous results are reported in several other studies. Afonso & Gonzàlez-Alegre (2008), for example, using GMM methodology and data from the EU-15 countries for 1970-2006, present evidence implying that fiscal deficits always have a positive effect on growth (even if it is not always significant). Morgese-Borys *et al.* (2008) report a small but always growth-enhancing effect of deficits for the 12 new-EU member states during 1994-2005. The results in Gemmell *et al.* (2011), based on data from 17 OECD countries for 1970-2004 and dynamic pooled-mean group regression methods, also fail to show that fiscal deficits are necessarily growth-reducing when potential endogeneity between the fiscal variables and growth is accounted for by excluding contemporaneous effects.

These results suggest that despite the growing number of studies, the channels through which fiscal deficits affect growth still are not well documented in the existing empirical literature and that the correct specification of the model has still not been found. Indeed, to examine the relationship between fiscal deficits and growth one needs an indicator of the extent to which current deficits are perceived by the markets as being associated with higher risks.[5] Fiscal deficits may result from excessive consumptive expenditures. Such deficits can be expected to slow down growth, since they will signal the possibility of an unsustainable public-sector position and poor macroeconomic performance in the future and, consequently, reduced long-term investment opportunities and lower profit margins. Deficits, however, may also result from the financing of activities that improve private productivity, associated with certain social and infrastructure services (educational, health-care and law & order services, active labour-market programmes, transport and information & communication services), as well as with R&D activity. In these cases, deficits may well be growth-enhancing by increasing aggregate productivity.[6] Moreover, such deficits are unlikely to entail higher future risks, since they will tend to be self-correcting and thus temporary, as the higher growth rates and per-capita incomes induced by the increased productivity will generate additional public revenue in the longer term.

The extent to which current fiscal deficits entail higher risks can be expected to be related to the prospects of the economy, as seen by the markets, which can be proxied by alterative measures of economic uncertainty. If uncertainty is above a certain threshold, existing fiscal deficits are most likely to reflect an excessive public-sector position, thus leading to lower investment and growth in the longer run. If, on the other hand, low uncertainty prevails, even a large current fiscal deficit is likely to reflect debt-financed spending that will pay off in the future, or short-run fiscal adjustment to exogenous shocks that will subsequently be reversed. Accordingly, in such cases, current fiscal deficits are most likely to be seen by the markets as phenomena that entail no potential dangers in subsequent years, in which case they will have no adverse impact on output growth.

This paper adds to the existing literature in two ways: first, while taking explicitly into account the implications of the government budget constraint, we let the data tell to what extent, and under what circumstances, fiscal deficits can have non-negative growth effects; second, we construct various measures of uncertainty as proxies for the state of the economy and examine how their interactions with fiscal deficits impact on economic growth in an attempt to identify asymmetric effects. Much of the existing empirical literature on fiscal policy and growth implicitly assumes a balanced budget or simply adds government-activity variables to reduced-form convergence equations, neglecting the implications of

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[5] In the majority of the existing analytical studies the government is assumed to continuously run a balanced budget. Lin (2000), Greiner & Semmler (2000), Gosh & Mourmouras (2004), Adam & Bevan (2005), Minea & Villieu (2009), Greiner *et al.* (2007) and Greiner (2010) are among the few analytical studies in which the government budget constraint is explicitly considered and alternative methods of financing public expenditures are examined. Even in empirical studies, the implications of the government budget constraint are often neglected.

[6] Blankenau *et al.* (2007); Agénor (2008, 2010); Romp & de Haan (2007); DeLong & Summers (2012).

the government budget constraint in terms of empirical specification and interpretation of results. In this paper, we allow the government to run deficits, and, by taking explicitly into account government financing, we obtain directly from a structural model an asymmetric relationship between fiscal policy and growth, where the effect on growth of deficits depends on the prospective return as well as the perceived risks from current fiscal deficits which we proxy by various economic-uncertainty measures.

Uncertainty and changing market sentiments are increasingly seen in the macro-policy literature as factors that can have a profound effect on how the deficit- and debt-dynamics of a country are perceived. De Grauwe (2012), for example, shows that a country can be driven into a 'bad' equilibrium, which makes default more likely, if an uncertain economic environment and unfavourable market sentiments make investors fear default. De Grauwe & Ji (2013) present estimates suggesting that part of the increase in government bond rates in the eurozone countries during 2010-2011 was unrelated to changes in economic fundamentals and were due to extreme market sentiments of distrust. Aizenman *et.al.* (2013) report similar results, suggesting that the eurozone periphery default risk in 2010 was priced much higher than that of other economies with the same fundamentals, partly because of self-fulfilling market pessimism in an uncertain macroeconomic environment. Uncertainty and changing market sentiments are also examined in a recent study by Baker *et.al.* (2013) for the US, which, constructing a new policy-related uncertainty index and using simple VARs, finds innovations in the index to be associated with significant and persistent declines in industrial production and aggregate employment.[7]

III. Theoretical underpinnings and empirical specification

III.a A structural growth model

In line with much of the recent growth literature, we assume that increases in public expenditures have the potential to enhance the resource base of the economy by improving the quality, and/or increase the supply, of all private input factors. If income-tax revenue remains unchanged, the resulting fiscal deficit can be seen as an instrument to finance this additional public spending. This leads to an indirect effect of deficits on growth. Following Barro (1990) and much of the more recent growth literature (Adam & Bevan (2005); Futagami *et.al* (2008); Minea & Villieu (2009)), we model public expenditures as a flow variable.

Thus, on the supply side, output, *Y*, can be assumed to be produced with a simple, constant-returns-to-scale technology, according to the production function (1a):[8]

$$Y(t) = A(E_L L(t))^{a} (E_K K(t))^{(1-a)} \tag{1a}$$

$$\text{with} \quad A = E_A A_0 \,, \; E_A = (G/Y)^{\mu} \,, \; E_L = (G/Y)^{\beta} \,, \; E_K = (G/Y)^{\delta} \,, \; \mu, \beta, \delta \geq 0$$

[7] Other studies have focused on the impact of uncertainty on financial flows, while there is an extensive literature on the effects of uncertainty on firm investment (see e.g. the papers cited in Drakos & Goulas (2006, 2010)). The link between the growth effects of deficits and economic uncertainty has not been studied in the empirical literature.The growth-uncertainty relationship is often examined in the context of reduced-form models, in which the driving forces behind this relationship are not made explicit (Döpke (2004); Asteriou & Price (2005); Imbs (2007); Bredin & Fountas (2009); Furceri (2010)).

[8] Alternatively, public spending could be specified as a stock variable, in which case *G/Y* in (1a) would correspond to public investment as percent of GDP and a public-capital accumulation function would have to be added. This would complicate the model, while there would be little difference as far as steady-states were concerned (see e.g. Futagami *et al.* (1993)).

where L and K are labour and private capital respectively, α is the labour share in output, A_o is a technology variable (constant over time, for simplicity) and E_L, E_K and E_A are labour-, capital- and technology-enhancing factors, assumed to be positively related to government activity, as measured by the share of public expenditures in GDP, *G/Y*. μ, β and δ are non-negative constants representing the return to public purchases. Transport, electricity and water services, as well as services related to the maintenance of law & order and property rights, are examples of public services that can be taken to have a capital-enhancing effect and thus can be assumed to be associated with a positive δ. Educational services, health-care services, active labour-market policies and law & order services are examples of public services that can be expected to have a labour-enhancing effect and thus lead to a positive β, while the government's involvement in R&D activity can be taken to correspond to technology-enhancing public services leading to a positive μ. Expressing Y and K in per capita terms ($y = Y/L$, $k = K/L$), output supplied can be written in condensed form as[9,10]

$$y(t) = A_o g^{*\theta} k(t)^{(1-a)} \tag{1b}$$

with $\theta = \mu + \beta a + \delta(1-\alpha)$, $g^* = g/y = (G/L)/(Y/L)$

where θ measures the total return to public purchases, while g^* can be interpreted as the amount of public services provided (in per capita-terms) as percent of GDP.

On the demand side, in the absence of unexpected events, $y(t)$ is the sum of planned private consumption $c(t)$, total planned private investment $i(t)$, and overall public spending $g(t)$, all defined in per capita terms (i.e. $c = C/L$, $i = I/L$, $g = G/L$):

$$y(t) = c(t) + i(t) + g(t) \tag{2a}$$

The excess of households' income over consumption, $y(t) - c(t)$, equals private savings, $s(t)$, plus total tax payments $\tau(t)$, while planned private investment consists of replacement investment and net additions to the (per-capita) capital stock, that is, $i(t) = (n+\delta)k(t) + \dot{k}(t)$ where δ is the depreciation rate of capital,[11] n is the rate of labour-force growth (assumed exogenous) and $\dot{k}(t) = dk/dt$. If we further assume that agents save a constant proportion s_y of their after-tax income $y(t) - \tau(t)$, we can write the equilibrium condition in the goods markets as:[12]

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[9] Specifying (1a) as a function of *(G/Y)* corresponds more closely to the idea that public services are non-rival and non-excludable, although making the factor-enhancing terms E_L, E_K and E_A a function of the per capita government services rather than a function of the amount of public services provided as percent of GDP would not change the main predictions of the model.

[10] To the extent that the size of government, as measured by the share of public expenditures in GDP, reflects socio-economic considerations and elements related to the decision-making process at the political level, g^* can be treated as a policy instrument, and so it is specified as time-invariant. Over time the government sets g to grow at the same rate as y so g^* is constant.

[11] The rate of labour-force growth, n, enters in net capital depreciation as $k(t)$ is measured in per-capita terms.

[12] Note that since the excess of households' income over consumption equals private savings plus tax payments, we can write (2a) as $s_y[y(t) - \tau(t)] + \tau(t) = i(t) + g(t)$, or $s_y\left(y(t) - \frac{\tau(t)}{y(t)}y(t)\right) + \frac{\tau(t)}{y(t)}y(t) = i(t) + \frac{g(t)}{y(t)}y(t)$. Then, denoting the ratio of total tax revenue to GDP, $\frac{\tau(t)}{y(t)}$, by $\tau^*(t)$ and substituting out $i(t)$ we obtain (2b).

$$[s_y + \tau^*(t)(1-s_y) - g^*]y(t) = \left(n+\delta\right)k(t) + \dot{k}(t) \quad (2b)$$

where both government-activity variables, g*and tax revenues τ*= τ /y = *(G/L)/(Y/L)*, are scaled in terms of GDP.

Combining (2b) with (1b) gives the rate of capital accumulation as:

$$\gamma_k(t) \equiv \frac{\dot{k}(t)}{k(t)} = [s_y + \tau^*(t)(1-s_y) - g^*]A_O g^{*\theta}\, k(t)^{-a} - (n+\delta) \quad (3)$$

Abstracting from the option of issuing money,[13] higher public spending can be financed either from increased tax revenue or from new-debt issues. Thus, the government's budget constraint is

$$g^* = \tau^*(t) + \dot{b}^*(t) - [r(t) - \gamma_y(t) - n]b^*(t) \quad (4a)$$

where $b^* = b/y$ = *(B/L)/(Y/L)* is the debt-to-GDP ratio, $\dot{b}^*(t) = db^*/dt$ and the last term on the right-hand side represents net government outlays on interest payments. $r(t)$ is the real interest rate on government debt, which, under competitive assumptions, can be taken to equal the net return to capital, i.e. the marginal product of capital minus the depreciation rate $\frac{\partial y(t)}{\partial k(t)} - \delta$, while $\gamma_y = \frac{\dot{y}(t)}{y(t)}$ is the growth rate of (per-capita) output, which, for a given A_o and a time-invariant g^*, is uniquely linked to the growth rate of k (i.e. from (1b), $\gamma_y(t) = (1-a)\gamma_k(t)$). Rearranging terms in (4a) and substituting out $r(t)$, using $\frac{\partial y(t)}{\partial k(t)} = \frac{(1-a)A_o g^{*\theta}}{k(t)^a}$ and the arbitrage condition that the real interest rate on public debt equals the net return on capital , we can write the government budget constraint as:[14]

$$\dot{b}^*(t) = g^* - \tau^*(t) + \omega(t)b^*(t) \quad (4b)$$

$$\text{where } \omega(t) = [\frac{(1-a)A_O g^{*\theta}}{k(t)^a} - (1-a)\gamma_k(t) - (\delta+n)] \lessgtr 0$$

From (4b), if τ^* is held constant, any increase in g*, for an unchanged k, will lead to a deficit, both directly, and indirectly through the rise in the real interest rate on outstanding debt, via the positive impact of the higher g* on capital productivity (i.e. via the first term in $\omega(t)$).Over time b* will rise and, unless the capital stock is growing quickly enough to ensure that, given δ and n , along the adjustment path $\omega(t) < 0$ in (4b), the rising b* will be followed by increased government outlays on interest payments. For an unchanged capital stock *k(t)*, the risk of a self-fuelling explosion of public debt, and therefore an unsustainable public-sector position, can be eliminated if the additional government outlays on interest payments are accompanied by a primary surplus relative to GDP, and thus, for a given government share in GDP, g^*, are financed by higher tax revenue. Accordingly, if the government is capable of enforcing a

[13] This option is not available to most of the countries in our sample.

[14] All public debt is domestically held, for simplicity. Interest income from public-debt holdings can be included in households' disposable income (at the expense of more complicted algebra) with no substantive change in the results as long as the tax rate on these interest payments is between 0 and 1.

debt-stabilization rule[15] that leads to higher tax revenue to GDP as the debt-to-GDP ratio rises, of, for example, the form $\tau_b = \rho b^*$, then the government's receipts as percent of GDP will be

$$\tau^*(t) = \tau_y + \rho b^*(t)\ , \rho > 0\ , \tag{5}$$

and, combining (5) with (4b), debt accumulation relative to (per capita) GDP will be given as:

$$\dot{b}^*(t) = g^* - \tau_y - \zeta(t) b^*(t)\ , \zeta(t) = \rho - \omega(t)\ , \tag{6}$$

where τ_y represents the (average) income-tax rate (revenue from ordinary income taxes as percent of GDP), which can be treated as a policy instrument (and therefore is specified as time-invariant), while ρ measures the government's response to rising debt and therefore the weight it puts on debt stabilization. For a sufficiently strong government reaction to rising debt (a large enough ρ), the sign over time of $\zeta(t)$ will unambiguously be positive even if the capital stock is not growing quickly enough to ensure that over time $\omega(t) < 0$, in which case, along the dynamic adjustment path, changes in the debt-to-GDP ratio will gradually dampen out and the potential danger of an explosive debt process, and therefore an unsustainable public-sector position, will be eliminated.

Similarly, combining (5) with (3), gives the rate of capital accumulation as:

$$\gamma_k(t) \equiv \frac{\dot{k}(t)}{k(t)} = [s_y + (\tau_y + \rho b^*(t))(1 - s_y) - g^*] A_O g^{*\theta} k(t)^{-a} - (n + \delta) \tag{7}$$

Assuming dynamic stability, the solution to (6)-(7) leads to steady-state responses of per-capita capital to changes in the fiscal-policy instruments g^* and τ_y given by (8) (see Appendix A):

$$dk_\infty = (\lambda_1/\eta) dg^* \ + \ (\lambda_2/\eta) d\tau_y \tag{8}$$

where

$$\lambda_1 = -(1 - \frac{\theta i^*}{g^*}) + [(\frac{1}{\zeta})(1+\phi)\rho(1-s_y)]\ , \quad i^* = i/y, \quad \phi = b^*(1-a)(y/k)(\frac{\theta}{g^*})$$

$$\lambda_2 = -(1-s_y)(\frac{\omega}{\zeta})\ , \quad \eta = [i^* + (1-a)(y/k) b^* (\frac{\rho}{\zeta})(1-s_y)] a (1/k) (> 0)$$

The sign of λ_1 is a priori unclear. With deficit financing, and therefore an unchanged τ_y, increases in public purchases imply that the government absorbs resources that could have been used for private investment. At the same time, the higher g^* improves the resource base of the economy, through the factor-enhancing terms E_L, E_K and E_A, leading to an expansion of output y, which in turn leads to higher private savings and increased tax revenues. θ, the total return to government purchases, determines the size of the increase in per-capita output resulting from the factor-enhancing effects of the higher fiscal expenditures, while the larger the saving rate and initial income-tax rate the greater the resources that become available for investment as output rises following the increased fiscal purchases. Thus, if θ is

[15] The evidence is consistent with this assumption. For the eurozone countries, for example, a debt-stabilization rule like (5) could be interpreted in the context of the Maastricht Treaty since the Stability & Growth Pact constraints member states to maintain a debt-to-GDP ratio below 60%. In the UK the Code of Fiscal Stability constraints the government to keep the debt-to-GDP ratio below 30% (see e.g.Chote (2009)), while similar budgetary rules are used in other countries, including Japan. Analytical growth studies that include public debt are Greiner & Semmler (2000), Gosh & Mourmouras (2004), Futagami *et al.*(2008), Minea & Villieu (2009), Greiner *et.al.*(2007) and Greiner (2010).Although these studies explore the growth and welfare effects of alternative financing methods, none of them explicitly considers the dynamic-stability implications of the government budget constraint in terms of the empirical specification of growth equations and in terms of interpreting the empirical results.

large, the increase in savings and tax revenue induced by the higher y may compensate for the rise in government spending, leaving on balance a larger quantity of output available for investment, i^*. In such a case, provided that the initial public-spending-to-GDP ratio is not excessive, the first term in λ_1 (i.e. $-(1-\frac{\theta\, i^*}{g^*})$) will have a positive sign. Additionally, with deficit-financing, we have in λ_1 the bracketed term, whose sign and size can be viewed as reflecting the potential dangers, as seen by the markets, associated with fiscal deficits. Firstly, if the state of the economy is expected to be poor, the markets will not preclude the possibility that $\zeta < 0$, in which case the government will have problems servicing its debt and may not avoid default or end up reducing public expenditures in order to accomplish a primary surplus. The risk will be higher the less determined is the government to enforce a debt stabilization rule like (5), since a weak government reaction, ρ , to rising debt may not ensure that $\zeta > 0$, particularly if the capital stock is not large enough to imply a relatively low real interest rate. Secondly, even if ζ is positive, unless ρ is large, the rise over time in public debt resulting from the initial deficit (whose size is reflected in $(1+\phi)$) may not be followed by a large enough reduction in private consumption to allow for sufficient resources to be spent, along the adjustment path, on investment and thus on capital accumulation. Accordingly, if the state of the economy is not expected to be satisfactory, the second term in λ_1 may be negative, or, if positive, it will be small in size. This, if combined with an insufficiently large overall return to public expenditures θ , can lead to a lower steady-state capital stock ($\lambda_1 < 0$). The reverse will be true if the government's determination and credibility to enforce a debt-stabilization rule like (5) is beyond doubt and the capital stock is large enough to imply a relatively low real interest rate and therefore limited government outlays on interest payments. In this case, both ρ and ζ will be positive, with the result that the bracketed term in λ_1 will unambiguously be positive and relatively large in size. If this is combined with a strong enough return to public spending θ , it may well lead to $\lambda_1 > 0$. In short, with deficit-financing, the better the prospects of the economy, and thus the more weight the government attaches to debt stabilization and the lower the real interest rate, the more likely it is that the resource-enhancing effects of higher public purchases will, on balance, lead to an increased capital stock in the long run and therefore more growth between steady states. By contrast, if the government were to continuously run a balanced-budget, the effect of the higher government spending on steady-state capital would reduce to $-[s_y - (\frac{\theta i^*}{g^*})](\frac{1}{\eta})$.[16]

IIIb. Empirical specification

[16] If the government were to continuously run a balanced-budget, then in (8) we would have $b^* = 0$ and $d\tau_y = dg^*$.

For estimation purposes we need an expression for the evolution of per capita output in terms of measurable variables. Imposing the steady-state condition $\gamma_k(t) = \dot{b}^*(t) = 0$ and combining the resulting expressions in (7) and (6) with (1b),[17] we can write the steady-state (per-capita) output, y_∞, as:

$$y_\infty = \frac{A_o^{1/a}}{(n+\delta)^{(1-a)/a}}(g^{*\theta/a})[s_y(1-\tau_y)-(g^*-\tau_y)[1-(1-s_y)(\frac{\rho}{\zeta_\infty})]]^{(1-a)/a} \tag{9a}$$

$$\text{with} \quad \varsigma_\infty = \rho - \frac{(1-a)A_o g^{*\theta}}{k_\infty{}^a} + (\delta+n)$$

Outside steady states, along the adjustment path, and with a time-invariant *g**, the path of (per capita) output will be determined by the path of *k*. Letting $\psi(t)$ be the rate at which the (log of) per-capita capital, $\ln k(t)$, approaches (the log of) its steady-state value, $\ln k_\infty$, and denoting by $\ln y_o$ an initial steady-state per-capita output, outside steady states we can write as an approximation:[18]

$$\ln y(t) - \ln y_\infty = e^{-(1-a)\psi(t)}(\ln y_o - \ln y_\infty) \tag{9b}$$

or

$$\ln y(t) - \ln y_o = (1-e^{-(1-a)\psi(t)})(\ln y_\infty - \ln y_o) \tag{9c}$$

Upon substitution into (9c) of a linearized version of (9a) by taking derivatives, and making use of the expression for k_∞ obtained from the steady-state solution of the model (see Appendix A), we can derive an output-growth equation of the form given by (10):

$$d\ln y(t) = \upsilon(t)F\left(A_o, s_y, n+\delta, g^*, \tau_y\right) - \upsilon(t)\ln y \tag{10}$$

where

$$d\ln y(t) = \frac{\ln y(t) - \ln y_0}{t}, \quad \upsilon(t) = \frac{(1-e^{-(1-a)\psi(t)})}{t} > 0$$

and

$$F_{A_o} = (1+\frac{(1-a)i^*}{\sigma a})(\frac{1}{A_o}),\ F_{s_y} = (1-\tau_y)\frac{(1-a)}{\sigma a},\ F_{n+\delta} = -\frac{(1-a)}{\sigma a(n+\delta)}[i^*+(1-s_y)b^*(\frac{\rho}{\zeta})(n+\delta)],\ F_{\tau_y} = -\frac{(1-a)}{\sigma a}(1-s_y)(\frac{\omega}{\zeta}),$$

$$F_{g^*} = \left(\theta - [1-(1-s_y)(\frac{\rho}{\zeta})](1-a)(\frac{g^*}{\sigma})\right)\sigma_1,\ \sigma = [i^*+(1-a)(y/k)(1-s_y)(\frac{\rho}{\zeta})b^*]\ (>0),\ \sigma_1 = \frac{1}{g^*a} > 0$$

F_{A_o} and F_{s_y}, the partial derivatives of output growth with respect to technology and private savings, respectively, are positive. $F_{n+\delta}$, the partial derivative with respect to the sum of population growth and depreciation rate has a negative sign, while the tax effect on growth, F_{τ_y}, will be negative if stable debt

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[17] Lettinng $\gamma_k(t) = 0$, from (7) we have $[s_y + (\tau_y + \rho b^*_\infty)(1-s_y) - g^*]\frac{A_o g^{*\theta}}{k_\infty{}^a} = (\delta+n)$ (7'). Letting $\dot{b}^*(t) = 0$ in (6), solving for b^*_∞ and inserting the resulting expression into (7') we can write $[s_y(1-\tau_y) + \rho(g^*-\tau_y)(\frac{1}{\zeta_\infty})(1-s_y) - (g^*-\tau_y)]\frac{A_o g^{*\theta}}{n+\delta} = k_\infty^a$, or $[s_y(1-\tau_y) - (g^*-\tau_y)(1-(1-s_y)(\frac{\rho}{\varsigma_\infty}))]^{1/\alpha}(\frac{A_o g^{*\theta}}{n+\delta})^{1/\alpha} = k_\infty$ (7''). Combining (7'') with (1b), yields equation (9a).

[18] See e.g. Mankiw *et al.* (1992) and Bassanini & Scarpetta (2001).

dynamics require a strong government reaction to rising public debt (i.e. if $\omega > 0$). The sign of the partial derivative with respect to government spending, F_{g*}, holding the income-tax rate τ_y constant, depends on the magnitude of θ, and thus on the overall return to public expenditures, as well as on the sign and size of ρ/ζ, and thus on the requirement for a sustainable public-sector position. If the state of the economy, including the potential for a strong productivity-enhancing effect of public spending and for a strong government determination to maintain fiscal sustainability, is sufficiently satisfactory, then deficit-financed increases in public expenditures are more likely to have a favourable effect on output growth ($F_{g*} > 0$) than income-tax-financed increases.[19] On the other hand, whether or not the economy meets the requirements for fiscal sustainability can be taken to represent the perceived risks associated with any current deficit that arises from increases in government expenditures. Such risks can be expected to be related to the overall prospects of the economy, as seen by the markets, which we proxy with various uncertainty measures. These uncertainty measures are based on the variability of industrial production, stock-market returns and survey-based economic-sentiment indicators.

In particular, we classify a country as facing a higher degree of uncertainty, $HUNC_{j,t}$, when the annual (conditional or unconditional) standard deviation of the corresponding variable (i.e. industrial production index, stock market returns and economic-sentiment indicators) is above the median value obtained from the distribution of all countries. In the opposite case, a country is classified as facing a lower degree of uncertainty, $LUNC_{j,t}$.[20]

Thus, the empirical specification, which corresponds to (10), is given by (11):

$$d\log\left(GDP\right)_{j,t} = \delta_1 \log\left(GDP\right)_{j,t-1} + \delta_2\left(FISCAL * HUNC\right)_{j,t} + \delta_3\left(FISCAL * LUNC\right)_{j,t} + \delta_4\left(TAX\right)_{j,t} + \\ + \delta_5\left(SAV\right)_{j,t} + \delta_6\left(TEC\right)_{j,t} + \delta_7\left(HUM\right)_{j,t} + \delta_8\left(GAP\right)_{j,t-1} + \sum_{t=1991}^{2007} \tau_t\left(year\right) + \mu_j + \varepsilon_{j,t} \tag{11}$$

The δ_i's, τ_i's are unknown constant parameters to be estimated, μ represents unobserved country-fixed effects and ε is an unobserved spherical disturbance term. The dependent variable, $d\log\left(GDP\right)_{j,t}$ is real output growth, measured by the annual percentage change of GDP per capita (US$ constant (2005, PPP) prices). $\text{Log}\left(GDP\right)_{i,t-1}$, the lagged value of (the logarithm of) GDP per capita, will enter the regression with a negative coefficient δ_1 if conditional convergence applies.[21] The fiscal variable $\left(FISCAL\right)_{j,t}$ refers to the general-government deficit as percent of GDP. *FISCAL* will enter the

[19] With income-tax financing and no initial debt *(b* = 0),* the effect of higher public spending would reduce to $[\theta - s_y(1-a)(\frac{g*}{\sigma})]\sigma_1$.

[20] A number of studies in the investment literature measure asymmetric effects in a similar way, see e.g. Leahy & Whited (1996), Drakos & Kalandranis (2005), Drakos & Goulas (2006) and Guariglia *et al.* (2013).

[21] According to the conditional convergence hypothesis, when macroeconomic policies and other key characteristics across countries and over time are accounted for, low/high levels of income per capita are associated with higher/ lower growth rates in subsequent years.

regression with a significantly negative, and large in size, coefficient if the productivity-enhancing effects of public expenditures are weak and the markets perceive that the state of the economy is not sufficiently satisfactory to ensure fiscal-policy sustainability. By contrast, *FISCAL* will enter with a non-negative coefficient if the return to public expenditures is sizable and the state of the economy, as seen by the markets, is satisfactory enough to eliminate the possibility of an unsustainable public-sector position. Accordingly, we anticipate rejecting the joint hypothesis of $H_0 : \delta_2 = \delta_3 = 0$ in favour of the alternative that at least one parameter is significant, providing evidence of an asymmetric response of growth to public deficits. For a negative and significant δ_2, we also anticipate that $|\delta_2| > |\delta_3|$ indicating that the growth-deficit elasticity is a function of the combined effect of the return to public expenditures and the perceived future risks associated with deficits, as reflected in the degree of uncertainty regarding the prospects of the economy. The tax variable, $(TAX)_{j,t}$, is measured as general-government revenue as percent of GDP, and its sign, holding *FISCAL* constant, can be expected to be negative. $(SAV)_{j,t}$ represents the saving rate, measured by the ratio of gross national income minus total consumption to GDP, whereas the level of technology, $(TEC)_{j,t}$, is proxied by the share of high-technology exports in total manufactured exports. We thus expect $\delta_5,\ \delta_6 > 0$. Following much of the empirical growth literature, human capital, $(HUM)_{j,t}$, is added as a separate explanatory variable in (11), with the corresponding coefficient δ_7 expected to be positive. $(HUM)_{j,t}$ is proxied by the ratio of (gross) tertiary enrolment to the population of the corresponding age group. In the set of explanatory variables we also include time dummies to control for common shocks across countries that may have taken place during the period under consideration, such as monetary-policy changes and other factors arising, for example, from the circulation of the euro.[22] Given the annual frequency of our data, we further include the initial per-capita output gap, $(GAP)_{j,t-1}$, to control for cycle effects, with $(GAP)_{j,t-1}$ been defined as $\log(GDP)_{i,t-1} - \log(GDP)^{tr}_{i,t-1}$, where the trend component of per-capita GDP, $\log(GDP)^{tr}$, has been obtained from a Hodrick-Prescott filter. Data on all variables except *TAX* and *FISCAL* come from the World Bank (*World Development Indicators* database). Series for *TAX* and *FISCAL* are obtained from the IMF (*World Economic Outlook*). Table B1 in Appendix B reports the statistical properties of the dataset.

IV. Construction of Uncertainty Measures and Estimation Results

We construct four measures of uncertainty, which differ both in terms of the methodology we employ to derive them and in terms of the forward-looking elements they contain. This serves to check the

[22] Time dummies can also serve as proxies for the average world-wide growth of technology. Population growth has not been included as an explanatory variable because the corresponding series for the sample we consider shows very little variation across countries and over time.

robustness of the results with respect to using alternative uncertainty proxies.[23] In particular, we use two conditional measures of uncertainty, derived from pooled-panel- and simple time-series-GARCH models, and two unconditional measures arising directly from the standard deviation of the corresponding variables. The main advantage of conditional measures is that they reflect the information available at the time of decision making.

Thus, firstly, uncertainty is proxied by the conditional standard deviation of changes in the industrial (manufacturing) production index. We use annual data, obtained from the OECD database,[24] and conditional uncertainty, $(\sigma)_{j,t}^{pro}$, is calculated by applying a Pooled Panel-GARCH (PP-GARCH, hereafter) model. PP-GARCH models combine typical panel modeling assumptions with the assumption that the error term is multivariate normal, with a time varying conditional variance-covariance matrix. Thus, these models account for conditional heteroskedasticity and cross-sectional dependence in panel data. In particular, we estimate the following autoregressive model:

$$P_{j,t} = \theta_0 + \theta_1 P_{j,t-1} + \eta_{j,t} \tag{12a}$$

where $(P)_{j,t}$ is the annual change in the industrial (manufacturing) production index, the θ_i's stand for estimable parameters and η is a disturbance term. We assume that $\eta_{j,t} \sim N\left[0,\ \Omega_{j,t}\right]$, *i.e.* are multivariate normal error terms with a time-varying conditional variance-covariance matrix producing a PP-GARCH model (Cermeño & Grier (2006)). The variance-covariance matrix $\Omega_{j,t}$ is time-dependent and its diagonal and off-diagonal elements are given by the following equations:

$$\sigma_{j,t}^2 = \alpha + \sum_{n=1}^{p} \delta_n \sigma_{j,t-n}^2 + \sum_{m=1}^{q} \gamma_m \eta_{t-m}^2, \quad for\ \ j = 1,...N \tag{12b}$$

$$\sigma_{j,s,t} = \kappa + \sum_{n=1}^{p} \lambda_n \sigma_{j,s,t-n} + \sum_{m=1}^{q} \rho_m \eta_{j,t-m} \eta_{s,t-m}, \quad for\ j \neq s \tag{12c}$$

[**Table 1, about here**]

where (12b) is the conditional-variance equation and (12c) the conditional-covariance equation, with both equations implying that the conditional variance and covariance process follow the same dynamics.[25] The preferred model was chosen using the Akaike Information Criterion, which led to the adoption of a PP-ARCH (1) model. Table 1 reports the estimation results. The fitted values from the conditional-variance equation are then recovered and used as proxies for uncertainty (see e.g. Engle (1982); Bollerslev (1986)). This measure of uncertainty possesses the desirable properties of being conditional, as well as being cross-sectional and time-varying.

[23] Baker *et al.* (2013) have recently constructed a new policy-related uncertainty index, based on the frequency of newspaper references to economic-policy changes, differences in forecasts about future economic policy, including tax and spending policy, and other indicators, which could also be used as an alternative uncertainty proxy. This index, however, is available only for 5 European countries.

[24] Note that for Bulgaria, Cyprus, Latvia, Lithuania, and Romania data are obtained from the Eurostat database.

[25] Modeling the conditional variance-covariance process in this way is convenient in a panel-data context since by imposing common dynamics to the variance and covariance processes across units, the number of parameters is reduced dramatically. Another convenient feature is that this model does not imply constant cross-sectional correlation over time.

Secondly, we consider conditional uncertainty arising from stock market returns $(R)_t$. A well-known result from the stock-market literature is that short-run volatility in financial time series tends to cluster, i.e. large changes in the price of an asset are often followed by other large changes, while small changes are often followed by other small changes. The most popular models to capture this volatility clustering are ARCH (Autoregressive Conditional Heteroskedasticity) models, which, by imposing an autoregressive structure on the conditional variance, allow volatility shocks to persist over time. Estimating such models, one can generate daily conditional standard deviations. Thus, in our case, daily closing prices, in local currencies, for stock market indices[26] have been obtained from *Datastream*[27] from 1/1/1991 to 31/12/2007 and conditional uncertainty $(\sigma)_{j,t}^{sto}$ is generated by applying standard time-series GARCH models to each country's stock-market index.

[**Table 2, about here**]

Table 2 reports the time series ARCH results for daily non-overlapping returns for each country. In all cases, the coefficients in the conditional-variance equations are highly significant, suggesting persistence in volatility, consistent with volatility clustering. Uncertainty for each country is proxied by the fitted values from the volatility equations, with the annual conditional standard deviation being computed as the average of the daily conditional standard deviations:

$$\sigma_t^{sto} = \frac{1}{D}\sum_{d=1}^{D}\sigma_{d,t}^{sto},$$

where D denotes the total number of days in a year. This measure of volatility, as it is based on stock-market data, is highly forward looking, and definitely more forward-looking than the previous conditional-volatility measure arising from industrial-production variability.[28]

Finally, we use two unconditional metrics of uncertainty, $(\sigma)_{j,t}^{isi}$ and $(\sigma)_{j,t}^{esi}$,by computing the annual standard deviation of the monthly changes in the seasonally-adjusted *Industrial Sentiment Indicator*[29] (*ISI*) and *Economic Sentiment Indicator*[30] *(ESI)*. The data cover the period from January 1991 to December 2007 and are obtained from Eurostat (*Business and Consumer Surveys*, Economic and Financial Affairs of the EU). To construct the high uncertainty dummy *(HUNC)* we classify a country as

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[26] The indices employed are as follows: ATX (Austria), BEL 20 (Belgium), BSE SOFIX (Bulgaria), CYPRUS GENERAL (Cyprus), PRAGUE SE PX (Czech Republic), OMX 20 COPENHAGEN (Denmark), OMX TALLINN (Estonia), OMX HELSINKI (Finland), CAC 40 (France), MDAX FRANKFURT (Germany), ATHEX COMPOSITE (Greece), BUDAPEST PRICE INDEX (Hungary), IRELAND SE OVERALL ISEQ (Ireland), MILAN MIDEX (Italy), OMX RIGA (Latvia), OMX VILNIUS (Lithuania), AMSTERDAM SE ALL SHARE (Netherlands), OSLO EXCHANGE ALL SHARE (Norway), WARSAW GENERAL INDEX (Poland), PORTUGAL PSI GENERAL (Portugal), BET COMPOSITE INDEX (Romania), MADRID SE GENERAL (Spain), OMX STOCKHOLM (Sweden), SWISS MARKET (Switzerland), FTSE ALL SHARE (UK).

[27] Data on SBI TOP (Slovenia) are obtained from the Ljubljana stock exchange, while data on SAX INDEX (Slovakia) are from the Bratislava stock exchange.

[28] Using unconditional rather than conditional uncertainty from stock market returns could easily introduced bias into the growth regressions as stock market returns may, to a certain extent, reflect bubbles.

[29] Due to unavailability of data for Norway and Switzerland, we resort to the amplitude-adjusted Business Confidence Indicator (*BCI*) obtained from the monthly indicators of the OECD database.

[30] Similarly, for Norway and Switzerland we utilize the amplitude-adjusted Composite Leading Indicator (*CLI*) obtained from the OECD database.

facing a higher degree of uncertainty when the annual unconditional standard deviation of the *ISI* or the *ESI* is above the median value obtained from the distribution of all countries. By similar way, we construct the low uncertainty dummy *(LUNC)* when the annual unconditional standard deviation of the *ISI* or the *ESI* is below the median value obtained from the distribution of all countries. Since the *ISI* and *ESI* are inherently forward-looking, these two measures of uncertainty are as close to *ex ante* uncertainty as possible. They also have the advantage of being a direct measure of perceived uncertainty to the extent that they are based on the answers of the business community rather than being estimated.

Summary descriptive statistics and correlation coefficients among the four different measures of uncertainty are given in Tables B1 and B2 in Appendix B.

Equation (11) has been estimated by applying the system-GMM technique (Arellano & Bover (1995), Blundell & Bond (1998, 2000)). This technique is extensively used in the recent panel-data growth literature to control for unobserved panel heterogeneity and simultaneously tackle endogeneity bias resulting from the possibility that one or more of the explanatory variables in the growth regressions may not be strictly exogenous (see e.g. Bond *et al.* (2001), Hoeffler (2002), Guariglia & Poncet (2008), Saidi & Aloui (2010), Yamarik (2010), Rooth & Stenberg (2012), Christiansen *et al.* (2013), Aisen & Veiga (2013). Indeed, a common feature of most empirical growth models is that causation between the dependent and the right-hand-side variables may in principle run in both directions, leading to endogeneity bias. Instead of searching for appropriate external instruments to address this problem, something quite difficult in panel data, in the system-GMM estimation suitably lagged levels and lagged first-differences of right-hand-side variables are used as instruments, ensuring that the estimates reflect causation running from the right-hand-side variables to the dependent variable and not vice versa. The system-GMM technique is also particularly appropriate when the period of study is relatively short and the problem of weak instruments causes large finite-sample biases and poor precision of the originally simple first-differences GMM-estimator. In the regressions in Table 3, given that most of the explanatory variables in (11) may in principle be affected by per-capita growth, all right-hand-side variables, except the time dummies, have been treated as potentially endogenous and have been accordingly instrumented.[31] The statistical adequacy of the model is established when the generated residuals do not exhibit second-order autocorrelation and the over-identifying restrictions are not rejected.

Estimation results are shown in Table 3 below. Column (1) shows estimates without controlling for perceived risks of higher deficits, proxied by the alternative uncertainty measures, while columns (2)-(5)

[31] System-GMM builds on two equations, the original growth equation, which can be written equivalently in levels as $\log\left(GDP\right)_{j,t} = (1+\delta_1)\log\left(GDP\right)_{j,t-1} + X'_{j,t}\beta + \mu_{j,t} + \varepsilon_{j,t}$ where *X’* is a vector containing explanatory variables, and a transformed first-differenced equation, i.e. $d\log\left(GDP\right)_{j,t} = (1+\delta_1)d\log\left(GDP\right)_{j,t-1} + dX'_{j,t}\beta + \varepsilon_{j,t}$. Valid lags of the un-transformed variables are used as instruments in the transformed first-differenced equation and valid lags of the variables in the transformed first-differenced equation are used as instruments in the levels equation. For potentially endogenous variables, valid lags in the transformed first-differenced equation are lags 2 or more. In the untransformed levels equation, lagged first differences of the potentially endogenous explanatory variables can be used as valid instruments. $d\log\left(GDP\right)_{j,t-1}$ can also be used as a valid instrument in the levels equation (see e.g. the discussion in Hoeffler (2002)).

report estimates after controlling for such risks. In all columns, the Sargan test of over-identifying restrictions confirms the joint validity of the instruments used, indicating that the model is well specified. The hypothesis of no second-order serial correlation is also not rejected.

[**Table 3, about here**]

The results in column (1) show a statistically significant positive effect on growth of savings and technology. The human-capital proxy also has a favourable effect on growth, with the corresponding coefficient being positive and highly significant. The tax variable takes the expected (negative) sign and is statistically significant, consistent with the results of other studies (Bleaney *et al* (2001); Afonso & Furceri (2010); Barro & Redlick (2011); Gemmell *et al.* (2011)), while the initial output-gap enters with a negative coefficient indicating cyclical reversal effects (Evans *et.al.*(1998); Mahmud (2008)). Moreover, the coefficient on lagged per-capita GDP is negative and significant, indicating conditional convergence for the set of countries in our sample and time period under consideration. At the same time, column (1) indicates a negative relationship between fiscal deficits and per capita output growth holding taxes constant, with the coefficient on *FISCAL* being significant at the 5% level.

In column (2), where uncertainly is based on the conditional volatility of the industrial (manufacturing) production index, the results regarding the deficit variable change drastically. The coefficient on $\left(FISCAL * HUNC\right)$ is not only larger in absolute magnitude relative to $FISCAL$ in column (1) but also highly significant. By contrast, the coefficient on $\left(FISCAL * LUNC\right)$ is not significantly negative. This suggests that the growth effects of fiscal deficits are indeed asymmetric: only deficits associated with high uncertainty regarding the state of the economy have strong growth-reducing effects. With low uncertainty, higher fiscal deficits exert no statistically significant adverse influence on growth. From equation (10), we know that this latter case can be taken to correspond to a situation of a strong productivity-enhancing element in government purchases (as would be the case for a large θ), together with a strong and credible government that is prepared to stabilize the public debt (as would be the case for a positive and large ρ).

Moreover, columns (3)-(5) indicate that this asymmetric growth effect is robust to alternative uncertainty measures: independently of whether uncertainty is based on stock-market returns or the *ISI* and *ESI*, allowing for low uncertainty always reduces the magnitude of the estimated coefficient of *FISCAL*, which now becomes insignificant, while allowing for high uncertainty always has the opposite effect, with the corresponding coefficients of *FISCAL* in columns (4)-(5) becoming highly significant and large in size. Thus, in all cases, at the 5% level we reject the hypothesis that both coefficients, δ_2 and δ_3, are jointly insignificant in favour of the alternative that at least one parameter is significant, providing evidence of an asymmetric response of growth to public deficits.

At the same time, throughout columns (2)-(5), the estimated coefficient of the tax variable, *TAX*, remains similar to column (1), indicating that, holding fixed public deficits, increases in taxes are always growth-reducing. The estimated coefficients of the other explanatory variables in columns (2)-(5) are also very similar to those in column (1), implying growth-increasing effects from higher savings and human capital and cyclical-reversal effects.

The overall conclusion to be drawn from Table 3 is that fiscal deficits cannot a priori be considered as being growth-reducing: the state of the economy matters. Low uncertainty regarding the state of the economy can be taken to imply that a higher current deficit will pay off in the future, through resource-enhancing effects, and that the government's determination to ensure stable debt dynamics is beyond doubt. On the other hand, high uncertainty can be taken to correspond to a situation where any existing deficits are associated mostly with excessive consumptive expenditures, rather than expenditures that will pay off in the future, and the state of the economy is not satisfactory enough to eliminate the possibility of an unsustainable public-sector position. Indeed, our results suggest that a tighter budget policy does not necessarily promote economic growth and that the prospects of the economy, as seen by the markets, play a crucial role.

V. Concluding Comments

The relationship between fiscal policy and per-capita income growth has received wide attention in the literature. The conventional view is that deficit-financed government purchases lower growth by crowding out private investment and by introducing distortions in product and financial markets. Nevertheless, the empirical evidence is inconclusive: while some studies find that growth is negatively related to measures of fiscal imbalance, other studies present evidence indicating no significant negative effect or report results suggesting a favourable growth-impact of fiscal deficits.

We do not find a general negative link between fiscal deficits and per-capita income growth. This is because, holding taxes constant, fiscal deficits will have an adverse effect on growth only to the extent that the overall return to the associated government purchases, through their impact on private-input factors' productivity, is limited and the corresponding deficits are perceived by the markets as implying significant risks due to the possibility of unsustainable fiscal positions. This can be expected to coincide with high uncertainty regarding the future state of the economy. On the other hand, deficits may not be as detrimental for growth as generally thought if the economy meets the requirement for a sustainable debt process and expenditures pay off in the future through increased private-input productivity, in which case existing fiscal deficits can be expected to coincide with low uncertainty regarding the performance of the local economy in subsequent years. Indeed, our results suggest an asymmetry in the way fiscal imbalances affect growth rates. Regardless of the measure of uncertainty used, we find that fiscal deficits have a strong negative effect on per-capita income growth in cases of high uncertainty and no significant adverse effect in cases of low uncertainty.

This result has important policy implications. To the extent that the macroeconomic environment remains fragile and uncertainty regarding the prospects of many economies is still an issue, perceived risks associated with current fiscal deficits are likely to continue in the future, even in countries with moderate debt burdens, slowing down the rate of economic growth. In the current macroeconomic environment, what seems to be needed are fiscal structures that allow for counter-cyclical fiscal policy, directed at stabilizing economic activity through the automatic stabilizers, together with actions by governments which can persuade the markets that any existing deficits may not be as harmful as traditional analysis suggests. This requires a higher prospective return from deficits, which can be achieved through deficit restructuring, with more financing directed at productive activities, including R&D, infrastructure & communication investment and educational and health-care services, which the markets associate with low risks, and less financing directed at consumptive activities. Such deficits will then provide short-term macroeconomic stimulus in a weak world economy and at the same time will set the stage for faster growth in the medium term through improved fiscal positions as any deficits will tend to be self-correcting. As a number of recent macro-policy studies stress (De Grauwe (2012); DeLong & Summers (2012); Lane (2012); Holland & Portes (2012); Baldacci *et al.* (2009)), other strategies, including unconditional fiscal tightening and intense austerity programmes of spending cuts and/or tax increases, may well be self-defeating at present.

Appendix A

Taking partial derivatives in (6)-(7), the linearized dynamics of the economy can be written as:

$$\begin{bmatrix} \gamma_k(t) \\ \dot{b}^*(t) \end{bmatrix} = V \begin{bmatrix} \hat{k}(t) \\ \hat{b}^*(t) \end{bmatrix} + M \begin{bmatrix} \hat{g}^* \\ \hat{\tau}_y \end{bmatrix} + H \begin{bmatrix} \hat{A}_o \\ \hat{s}_y \\ (\hat{n}+\hat{\delta}) \end{bmatrix} \qquad \text{(A.1)}$$

with

$$V = \begin{bmatrix} v_1 & v_2 \\ v_3 & v_4 \end{bmatrix},\ M = \begin{bmatrix} m_1 & m_2 \\ m_3 & m_4 \end{bmatrix},\ H = \begin{bmatrix} h_1 & h_2 & h_3 \\ h_4 & h_5 & h_6 \end{bmatrix}$$

$$v_1 = -i^*(y/k)(1/k)a < 0,\ v_2 = (y/k)(1-s_y)\rho > 0,$$

$$v_3 = -a(1-a)(y/k)b^*(1-i^*)(1/k) < 0,\quad i^* = i/y > 0,$$

$$v_4 = -[\zeta + b^*(1-a)(y/k)(1-s_y)\rho] \lessgtr 0,$$

$$m_1 = -(y/k)[1-(\theta i^*/g^*)] \lessgtr 0,\ m_2 = (y/k)(1-s_y) > 0,$$

$$m_3 = 1 + b^*(1-a)(y/k)[1+(\theta/g^*)(1-i^*)] > 0,$$

$$m_4 = -[1 + b^*(y/k)(1-s_y)(1-a)] < 0,\ h_1 = i^*(y/k) > 0,$$

$$h_2 = (y/k)(1-\tau^*) > 0,\ h_3 = -1 < 0,\ h_4 = b^*(1-a)(y/k)(1-i^*) > 0,$$

$$h_5 = -b^*(y/k)(1-\tau^*)(1-a) < 0,\ h_6 = -b^*a < 0$$

where the circumflex over the variables denotes deviations from an initial steady state. If $\zeta > 0$ the determinant of the state matrix $\det(V) = v_1v_4 - v_2v_3$, which equals the product of the two characteristic roots of the system, will unambiguously be positive, in which case (A.1) will have two roots of the same sign. For a positive ζ, the trace of the state matrix, $\mathrm{tr}(V) = v_1 + v_4$, which equals the sum of the roots, will also be unambiguously negative, in which case both roots will be negative and the system will be stable, converging to steady-state equilibrium. Assuming stability, the solution to (A.1) yields long-run responses of k and b^* to changes in the fiscal-policy instruments, g^* and τ_y, and in the other exogenous variables s_y, A_o and $n+\delta$, which can be obtained from (A.2):

$$\begin{bmatrix} \hat{k}_\infty \\ \hat{b}^*_\infty \end{bmatrix} = -V^{-1}M \begin{bmatrix} \hat{g}^* \\ \hat{\tau}_y \end{bmatrix} - V^{-1}H \begin{bmatrix} \hat{A}_o \\ \hat{s}_y \\ (\hat{n}+\hat{\delta}) \end{bmatrix} \qquad \text{(A.2)}$$

Appendix B

Table B1. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
$d\log\left(GDP\right)_{j,t}$ [a]	354	0.030	0.028	-0.080	0.136
$\left(HUM\right)_{j,t}$ [b]	354	0.522	0.159	0.196	0.949
$\left(SAV\right)_{j,t}$ [c]	369	0.227	0.061	0.088	0.400
$\left(TEC\right)_{j,t}$ [d]	365	0.146	0.099	0.019	0.475
$\left(TAX\right)_{j,t}$ [e]	369	0.428	0.079	0.260	0.616
$\left(FISCAL\right)_{j,t}$ [f]	369	0.018	0.040	-0.185	0.134
$\left(GAP\right)_{j,t\text{-}1}$ [g]	354	-0.002	0.024	-0.069	0.090
Uncertainty Metrics					
$\left(\sigma\right)_{j,t}^{pro}$ [h]	357	0.044	0.030	0.027	0.340
$\left(\sigma\right)_{j,t}^{sto}$ [i]	366	0.012	0.003	0.007	0.025
$\left(\sigma\right)_{j,t}^{isi}$ [j]	388	0.030	0.021	0.001	0.173
$\left(\sigma\right)_{j,t}^{esi}$ [k]	400	0.025	0.018	0.000	0.148

Notes: The sample consists of 27 European countries over the period 1991-2007. (a) The percentage change of real per-capita GDP. (b) Total enrollment in tertiary education as a percentage of the total population of the five-year age group following on from secondary school leaving. (c) Gross domestic savings as a percentage of GDP. (d) The ratio of high-technology exports to manufactured exports. (e) General government revenue as a percentage of GDP. (f) Budget deficit over GDP. (g) The initial percentage deviation of per-capita current GDP from trend. (h) Conditional standard deviation of the percentage change of the industrial production index. (i) Conditional standard deviation of stock market returns. (j) Unconditional standard deviation of the monthly changes in the Industrial Sentiment Indicator (ISI). (k) Unconditional standard deviation of the monthly changes in the Economic Sentiment Indicator (ESI).

Table B2. Correlations among the variables of the model

	$d\log(GDP)_{j,t}$ [a]	$(HUM)_{j,t}$ [b]	$(SAV)_{j,t}$ [c]	$(TEC)_{j,t}$ [d]	$(TAX)_{j,t}$ [e]	$(FISCAL)_{j,t}$ [f]	$(GAP)_{j,t\text{-}1}$ [g]	$(\sigma)_{j,t}^{pro}$ [h]	$(\sigma)_{j,t}^{sto}$ [i]	$(\sigma)_{j,t}^{isi}$ [j]	$(\sigma)_{j,t}^{esi}$ [k]
$d\log(GDP)_{j,t}$ [a]	1										
$(HUM)_{j,t}$ [b]	0.151	1									
$(SAV)_{j,t}$ [c]	-0.032	0.101	1								
$(TEC)_{j,t}$ [d]	-0.015	0.081	0.469	1							
$(TAX)_{j,t}$ [e]	-0.331	0.405	0.322	0.201	1						
$(FISCAL)_{j,t}$ [f]	-0.089	-0.468	-0.514	-0.273	-0.373	1					
$(GAP)_{j,t\text{-}1}$ [g]	-0.444	0.103	0.135	0.083	0.146	-0.111	1				
$(\sigma)_{j,t}^{pro}$ [h]	0.228	-0.189	-0.100	-0.090	-0.301	0.054	-0.213	1			
$(\sigma)_{j,t}^{sto}$ [i]	0.134	0.110	-0.119	-0.070	0.078	0.070	0.009	0.150	1		
$(\sigma)_{j,t}^{isi}$ [j]	0.152	-0.136	0.067	0.200	-0.199	0.232	-0.061	0.116	0.045	1	
$(\sigma)_{j,t}^{esi}$ [k]	-0.012	-0.271	-0.032	0.186	-0.127	0.329	0.028	0.066	0.124	0.791	1

Notes: see Table B1.

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TABLES

Table 1. Pooled Panel ARCH model for production index[a]

Regressor[b]	**Estimates (z-scores)**
Mean Equation	
constant	-0.015 (-1.42)
$(P)_{j,t\text{-}1}$	0.636^{***} (23.50)
Conditional Variance Equation	
constant	0.0007^{***} (8.61)
$\text{ARCH}(1)$	0.918^{***} (7.13)
Log-likelihood	692.82
Observations	384

Notes: [(a)] The percentage change of the industrial production index for manufacturing. [(b)] The term $(P)_{j,t\text{-}1}$ represents the first-order lag of the dependent variable. Numbers in parentheses denote z-scores. One, two, three asterisks denote significance at the 10, 5, and 1 percent level respectively. Time effects included.

Table 2. Time-series ARCH models for stock returns[a]

Regressor[b]	Austria	Belgium	Bulgaria	Cyprus	Czech Republic	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy
$(R)_{t-1}$	0.141***	0.145***	0.203***	0.120***	0.179***	0.105***	0.269***	0.133***	0.026*	0.132***	0.196***	0.116***	0.164***	0.155***
	(9.23)	(17.56)	(12.59)	(3.70)	(10.20)	(7.77)	(58.51)	(11.26)	(1.86)	(9.41)	(17.60)	(11.04)	(13.03)	(8.18)
$\text{ARCH}(1)$	0.258***	0.462***	0.835***	0.350***	0.309***	0.271***	0.980***	0.492***	0.204***	0.282***	0.311***	0.447***	0.252***	0.267***
	(16.07)	(21.47)	(17.48)	(9.29)	(12.85)	(13.97)	(31.38)	(23.13)	(12.13)	(16.24)	(15.32)	(26.33)	(14.12)	(13.93)
Log-likelihood	-6398.0	-5966.9	-2399.6	-1494.8	-5511.1	-6271.9	-5213.5	-8527.8	-7274.4	-5500.5	-7910.2	-7772.7	-6025.7	-4883.8
Observations	4433	4433	1565	865	3582	4433	3019	4433	4433	4433	4433	4432	4433	3390

Table 2 Cont. Time-series ARCH models for stock returns[a]

Regressor[b]	Latvia	Lithuania	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Switzerland	UK
$(R)_{t-1}$	0.125***	0.162***	0.058***	0.048***	0.303***	0.163***	0.320***	-0.031	0.244***	0.062***	0.111***	0.064***	0.060***
	(16.51)	(8.52)	(4.87)	(2.72)	(40.17)	(21.24)	(19.37)	(-1.33)	(11.45)	(4.05)	(8.58)	(5.97)	(5.71)
$\text{ARCH}(1)$	0.678***	0.372***	0.445***	0.257***	0.429***	0.593***	0.471***	0.137***	0.506***	0.237***	0.348***	0.389***	0.326***
	(24.09)	(11.76)	(16.81)	(12.28)	(20.58)	(22.96)	(17.64)	(8.48)	(10.88)	(14.05)	(17.64)	(19.71)	(15.88)
Log-likelihood	-3326.1	-2795.4	-5409.9	-4742.1	-8784.4	-5026.8	-4498.8	-4078.3	-1270.1	-6692.5	-7107.6	-6447.5	-5683.8
Observations	2084	2085	3391	3130	4358	4433	2531	2422	1184	4433	4433	4433	4433

Notes: [(a)] Dependent variable is the daily return of the corresponding stock market index. [(b)] The term $(R)_{t-1}$ represents the first-order lag of the dependent variable. Numbers in parentheses denote z-scores, while one, two, three asterisks denote significance at the 10, 5, and 1 percent level respectively. Intercepts are not reported. All models include time effects.

Table 3. System-GMM estimates of the growth model

Dependent Variable $d\log\left(GDP\right)_{j,t}$	**Model (1)**	**Model (2)[a]**	**Model (3)[b]**	**Model (4)[c]**	**Model (5)[d]**
Regressor			**Estimates (t-statistics)**		
$\log\left(GDP\right)_{j,t-1}$	-0.046*** (-7.82)	-0.050*** (-8.59)	-0.054*** (-10.10)	-0.050*** (-6.76)	-0.047*** (-8.18)
$\left(FISCAL\right)_{j,t}$	-0.112** (-2.53)	-	-	-	-
$\left(FISCAL*HUNC\right)_{j,t}$	-	-0.201*** (-3.97)	-0.147** (-2.79)	-0.246*** (-3.05)	-0.193*** (-3.14)
$\left(FISCAL*LUNC\right)_{j,t}$	-	-0.044 (-0.83)	0.008 (0.09)	-0.001 (-0.02)	-0.059 (-1.20)
$\left(TAX\right)_{j,t}$	-0.124*** (-2.85)	-0.125*** (-2.88)	-0.080** (-2.27)	-0.094* (-1.94)	-0.122*** (-3.30)
$\left(SAV\right)_{j,t}$	0.074* (1.98)	0.083** (2.13)	0.092** (2.48)	0.094** (2.50)	0.090** (2.70)
$\left(TEC\right)_{j,t}$	0.062*** (3.47)	0.072*** (4.27)	0.069*** (3.75)	0.067*** (3.26)	0.055** (2.72)
$\left(HUM\right)_{j,t}$	0.105*** (5.54)	0.108*** (6.03)	0.102*** (5.63)	0.091*** (4.92)	0.098*** (5.45)
$\left(GAP\right)_{j,t-1}$	-0.296*** (-5.31)	-0.320*** (-5.20)	-0.294*** (-5.26)	-0.298*** (-5.21)	-0.290*** (-5.58)
Observations	337	320	314	328	336
m_1	-3.11***	-3.19***	-2.95***	-3.14***	-3.10***
m_2	-1.27	-0.17	-0.86	-0.87	-1.08
Sargan Test	205.49 (p-val. 0.18)	194.06 (p-val. 0.24)	194.61 (p-val. 0.34)	190.08 (p-val. 0.42)	200.94 (p-val. 0.23)
$H_0:\delta_2=\delta_3=0$	-	$x^2 = 8.59$***	$x^2 = 3.88$**	$x^2 = 4.72$**	$x^2 = 5.47$**

Notes: Numbers in parentheses denote t-statistics, m_1 and m_2 are residual first and second order serial correlation tests, while Sargan stands for the over-identifying restrictions test. One, two, three asterisks denote significance at the 10, 5, and 1 percent level respectively. All models allow for robust standard errors. Time dummies are included in all specifications. **Source of uncertainty:** [(a)] Industrial Production Index (PP-GARCH estimation). [(b)] Stock Market Returns (Time-series GARCH estimation). [(c)] Industrial Sentiment Indicator (ISI). [(d)] Economic Sentiment Indicator (ESI). **List of Instruments:** In all models, instruments used in the first-differenced equation are $log(GDP)_{j,t-2}$, $(HUM)_{j,t-2}$, $(SAV)_{j,t-2}$, $(TEC)_{j,t-2}$, $(TAX)_{j,t-2}$, $(FISCAL)_{j,t-2}$, $(GAP)_{j,t-2}$. Instruments used for levels equation are $dlog(GDP)_{j,t-1}$, $d(HUM)_{j,t-1}$, $d(SAV)_{j,t-1}$, $d(TEC)_{j,t-1}$, $d(TAX)_{j,t-1}$, $d(FISCAL)_{j,t-1}$.