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TOTAL FACTOR PRODUCTIVITY (TFP) AND FISCAL CONSOLIDATION: HOW HARMFUL IS AUSTERITY?

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Abstract

Departing from the expansionary austerity literature, this study assesses empirically whether fiscal consolidation propagates changes in the supply side of the economy that can potentially influence total factor productivity. Using a panel dataset of 26 OECD countries over the period 1980-2016 and employing panel vector autoregressive and error correction model specifications, we present evidence of both short-run and long-run negative effects of fiscal consolidation on TFP. The short-run impact is disproportionately more damaging for the TFP of low debt countries, while, contrary to the expansionary austerity thesis, our empirical results would advise against spending-driven fiscal consolidation, since such consolidation undermines capacity due to the importance of government spending in shaping productive capital. Our results have serious policy implications for the implementation and design of fiscal adjustment programmes.

JEL Classification: E62, C23, H68

Keywords: total factor productivity, fiscal consolidation, OECD countries, austerity, growth

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1. Introduction

The existing literature examines the effects of austerity with emphasis on how fiscal consolidation impacts mainly on output and other macroeconomic fundamentals such as, consumption, investment and employment. This strand of literature mainly focuses on the demand side effects of austerity with empirical findings being far from conclusive. Intuitively, the central argument in this debate is whether austerity in the form of fiscal consolidation is expansionary, contractionary or neutral with reference to output. Early contributions of Blanchard (1990); Bertola and Drazen (1993); Sutherland (1997); Alesina et al (2002); Giavazzi and Pagano (1990, 1995); Ardagna (2004); Alesina and Perotti (1997) support empirically the existence of expansionary austerity effects. The expansionary fiscal contraction thesis found renewed support in the period following the 2007/8 financial crisis (Alesina and Ardagna, 2010), in an effort to reconcile fiscal consolidation efforts with growth and demand concerns. This literature argues –contrary to conventional Keynesian wisdom–that fiscal contraction stimulates economic growth by increasing private consumption and investment through several demand side channels and credibility effects. One such channel suggests, for instance, that increases in taxes today work in a precautionary fashion eliminating the need of larger increases in the future. Both consumers and investors perceive this as a policy signal for tax cuts in the future forming expectations for higher disposable income.

A crucial aspect that yet has not attracted attention in this literature is whether austerity propagates changes in the supply side of the economy that can potentially influence the growth rate of productivity. In other words, our knowledge is limited as to whether austerity programmes undermine the productive capacity of an economy through underinvestment in neuralgic sectors such as infrastructure, technology and innovation.[1] If this is the case then adverse effects are likely to spread affecting negatively the evolution of aggregate productivity in the long run. At the moment, the expansionary austerity literature tells us very little about whether

[1] Stiglitz (2015) in a similar line of reasoning argues that the decline in GDP during the crisis that can be accounted for by declines in physical and human capital falls short of the actual decline in GDP, therefore suggesting that there is a missing "dark matter" related to the effects of the prolonged crisis and austerity policies.

fiscal consolidation impairs or enhances measures of technical progress such as: Total Factor Productivity (TFP). The goal of the present study is to assess empirically the validity of two competing scenarios: productivity enhancing or productivity repressing austerity. TFP -as a measure of technical change- embodies substantial welfare implications that are highly informative of an economy's performance (Delgado et al. 2012; Hausmann et al .2014). The drivers of TFP include -among others- investment in public infrastructure, education and research and development (R&D). Traditionally, these are largely publicly funded sectors shaping the productive capacity of the national economy. Understanding the dynamics of the fiscal consolidation - TFP nexus becomes important from a policy perspective against the backdrop of recent evidence (Fernald et al, 2017) that highlights a substantial slowdown in TFP especially in the post 2009 period. The policy importance of our research question becomes even more crucial within a euro-area context with virtually no single economy exhibiting positive TFP growth since 2008 when the global financial crisis broke out (Van Ark, 2014). Is such evidence on TFP compatible with the expansionary fiscal contraction thesis which has anchored the politics of the austerity debate and offered the intellectual rationale for pursuing harsh fiscal consolidation in a number of advanced countries? Shedding more light on this question is all the more important both in the short and especially in the long run, since the productivity effects of austerity might not manifest themselves immediately.

The paper employs evidence from a sample of 26 OECD countries over the period 1980-2016 to explore various aspects of the fiscal consolidation-TFP relationship. The conventional approach used to identify austerity and more broadly discretionary fiscal policy adjustments is changes in the Cyclically Adjusted Primary Balance (CAPB). Alternatively, a "narrative approach" is employed that consults a wide range of contemporaneous policy documents that announce government fiscal actions (Devries et al., 2011). The latter approach has the advantage of avoiding endogeneity issues[2] and decomposing fiscal consolidation into spending cuts and tax

[2] For recent studies on the problem of endogeneity of fiscal consolidation decisions, see De Cos and Moral-Benito (2013 and 2016), Guajardo et al (2014), Yang et al (2015) and Breuer (2017).

hikes but at the cost of a shorter time period and a smaller group of countries.[3] The analysis departs from a Panel VAR econometric specification- regularly used in the expansionary austerity literature- to identify the evolution of TFP after fiscal consolidation episodes. This approach models only the short-run dynamics of the TFP-austerity relationship. To understand how fiscal adjustments drive TFP in the long run, we specify an Error Correction model (ECM) that allows for a convergence process towards long-run equilibrium. Productivity enhancing and productivity repressing effects from austerity might be both present in the sample impacting differently on countries with different levels of debt burden. Governments are likely to be proactive when encountering debt sustainability concerns, so any decision for contractionary fiscal action might have beneficial effects on productivity when debt to GDP exceeds a certain critical threshold. To capture the existence of such effects we separately replicate estimations for groups of countries with different levels of debt burden. Finally, with the use of historical data we decompose fiscal consolidation into spending cuts and tax hikes to identify whether TFP responds differently between the two components of fiscal consolidation.

The paper is structured as follows: the next section taking as a starting point the expansionary austerity literature agenda, reviews theoretical arguments that can be put forward regarding the fiscal adjustment-productivity nexus. Section 3 reports results from the response of TFP to fiscal consolidation episodes within a panel vector autoregressive (PVAR) framework. This part of the analysis also aims to identify whether patterns in the TFP-fiscal consolidation nexus vary with the level of public debt; section 4 establishes an Error Correction Model (ECM) to identify more systematically the short- and long-run dynamics of the TFP-fiscal adjustment relationship, discusses results and presents several robustness checks. Section 5 concludes.

[3] Historical narrative data was previously used in the expansionary austerity literature (Guajardo et al., 2014; Jordà and Taylor, 2016). These studies indicate that fiscal consolidation contracts private consumption and GDP growth. The magnitude of this effect is around to 0.75 and 0.65 percentage point losses after an one percent increase in fiscal consolidation.

2. Productivity and fiscal adjustments: theoretical considerations

The neoclassical thesis states that a sound fiscal policy is vital in achieving stable macroeconomic conditions that promote growth and prosperity (Daniel, 2006). This argument is further investigated in the expansionary austerity literature linking cuts in government spending to structural reforms aimed at improving public sector efficiency (European Commission, 2007). This effect is quantified in Alesina and Ardagna (2010) who find that a one percentage point higher government spending to GDP leads to a 0.75 percentage point lower growth.[4] On the basis of the neoclassical proposition, fiscal loosening can cause adverse effects on productivity mainly via crowding out private investment and triggering uncertainty.[5] Continuous loosening of the fiscal stance not only leads to higher interest rates but also discourages business and entrepreneurial activities, as the government usually focuses on unproductive spending with limited scope for substantial growth returns in the long run (Furceri and Sousa, 2011). Fiscal imbalances are commonly identified (Ardagna, 2004) in economies that fail to attract the appropriate level of private investment, which potentially leads to low levels of capital deepening and output per worker. The second channel mainly focuses on the uncertainty induced in the economy due to continuous loosening in the budgetary balance. The main source of uncertainty is how and when this unsustainable condition will be fixed to avoid unsustainability in debt accumulation. In other words, the policy objective that concerns primarily investors is whether fiscal consolidation will be implemented via spending cuts or higher average tax rates. The latter case is regarded as a main source of volatility and risk, which turns into a disincentive for private investment. In an unstable fiscal environment, the type and quality of investment is also questioned as investors prefer investment with short-term returns to long-term investment engagement that is typically more beneficial for productivity in the economy.

[4] Other evidence of expansionary austerity effects is found in Ardagna (2004) whereby a reduction of the primary spending to GDP ratio by one percentage point increases GDP growth by 0.5 percentage point. Romer and Romer (2010) show that increases in tax revenue are effective in reducing budget deficit without causing significant output losses.

[5] Other stimulative channels identified in the expansionary austerity scenario include credibility gains and lower inflation risks. There might also be gains in the labour market through cuts in public employment that stimulate wages and jobs in the private sector. A more detailed discussion for fiscal adjustment associated gains can be found in Daniel (2006).

On the other hand, the productivity of government spending is an important aspect of the puzzle when the effectiveness of fiscal policy is assessed. A major component of government spending in advanced economies is on developing and maintaining infrastructure which drives output in the private sector.[6] Causality has been found to run from public capital to aggregate productivity, which can be taken as evidence that inadequate public investment accounts for productivity slowdowns. Stagnation in the level of per capita income in advanced economies is usually attributed to factors related to insufficient public investment in sectors such as transport and energy (Van Reenen, 2013). The logic is straightforward, sectors with substantial potential for productivity spillovers are usually funded under public schemes; therefore any public underinvestment in periods of fiscal consolidation triggers negative consequences in a number of downstream sectors as well, resulting in overall lower productivity. Fernald (1999) ratifies this argument for roads building and economic growth in the US while Roller and Waverman (2001) find a similar result for telecommunication infrastructure for a sample of OECD countries. The elasticity of private output to changes in public investment varies across countries but it tends to be high even in cases of public investment in semi-productive activities (Leeper et al. 2010). [7]

Quite recently Rodrik (2016) casts doubt on another milestone underlying the expansionary austerity hypothesis: structural reforms. Austerity programmes are often accompanied with an ambitious structural reform agenda of a "big bang" type - do as many changes as possible, as quickly as possible. Such pro-market reforms include, for instance, deregulation of labour market (breaking union monopoly power), removal of barriers to entry, privatization of state assets. Although the overarching goal is to reallocate factors towards more productive sectors, any serious assessment of the actual results from structural reforms and their impact on aggregate productivity indicates much less optimism (Rodrik, 2016). A bold economy-wide liberalization programme as a complement of austerity might actually

[6] See Bom and Ligthart (2014) for a detailed meta-analysis on the productivity of public capital.
[7] Recent literature (Aghion et al, 2010 and 2014) point out that, in the presence of credit constraints, even cyclical fiscal adjustments can generate long run impacts through substitution of long-term productivity-enhancing investment for less productive short-term investment.

drive resources towards unproductive (low value added) sectors and the outcome achieved can be quite the opposite than a boost of aggregate productivity.[8]

On the whole, while existing literature focuses on the effect of austerity on an array of macroeconomic fundamentals with the fiscal adjustment-growth nexus still remaining fragile and without providing robust findings on any stand, there are reasons to suspect that tightening fiscal policy could also impact on productivity. The expansionary austerity literature so far remains silent on the sign and magnitude of such an impact which could play out both in the short and in the long run. The main contribution of our paper is to fill in this gap. At the same time, our analysis also improves our understanding of the recently highly topical policy debate on whether austerity could be self-defeating. The design and pace of warranted fiscal consolidation has become an issue of controversy with several authors arguing that reductions in deficits have ended up delivering higher debt-to-GDP ratios accelerating the effects of the negative debt-growth spiral (Ersoy and Yanmaz, 2016, Heimberger, 2017, House et al., 2017, Fatás and Summers, 2018). Although the debt-to-GDP ratio is not of primary concern in the present paper, exploring the effects of austerity on total factor productivity certainly provides a plausible line of reasoning one can put forward within a broader fiscal sustainability perspective.

3. Preliminary analysis

We gather data from 26 OECD countries over the period 1980-2016. The first attempt is to understand the raw correlation between TFP and fiscal consolidation over time and across countries. For the definition of fiscal consolidation, we rely on Blanchard (1993) who uses large observed improvements in the cyclically adjusted primary balance (CAPB). CAPB is intended to capture discretionary fiscal policy by excluding the estimated effects of business cycle fluctuations on the government budget. Therefore, taxes and transfers are cyclically adjusted with net interest payments to be subtracted. As the latter represent past government liabilities on

[8] Unless structural reforms are carefully planned as a targeted, selective removal of key obstacles impeding growth, this policy can eventually backlash even in the long run.

accumulated debt that have been excluded from CAPB, this measure can be considered as discretionary. Changes in the CAPB (d*capb*) can then be used to identify large-scale fiscal adjustments the so-called fiscal consolidation episodes (FCE).[9]

Figure 1 shows the time trend of changes in CAPB for each country in the sample. Although it is difficult to identify a universal pattern, there are groups that share certain similarities as far as the timing of austerity is concerned. Ireland, Iceland, Greece, Portugal and Spain implemented programmes of severe austerity in the early 2010 onwards. These countries agreed on a bailout programme for resolving issues with external debt sustainability. Such programmes imposed heavy conditionality for rapid, front-loaded fiscal adjustment. Germany adopted a programme of fiscal adjustment in the early 1990's following re-unification in 1991 while a similar pattern is also existent in the Netherlands for the same period. Japan adopted a mild programme of fiscal consolidation in mid-1990s while a similar consolidation programme seems to have been in place in the USA towards late 2000s in the aftermath of the 2008-9 financial-banking crisis when public bailout programmes were offered for rescuing the financial system.

Figure 2 plots linear fitted values of averages TFP growth rates versus average d*capb* for four sub-periods . On average, fiscal loosening in 1980's and 2000's is positively correlated with TFP, in 1990's there is no significant correlation between the two variables while only for the period after 2010 fiscal consolidation co-moves with gains in TFP. The graph also shows substantial variation in this correlation across countries and time periods. For instance, in the 2000-2010 period, Spain and the UK experience a d*capb* close to -1% but the average rate of TFP growth is substantially higher in the latter. A similar remark can be made for Austria and Greece with a similar rate of TFP growth over the same period but with large differences in d*capb* between the two countries. The 1990s is an era of fiscal discipline for many OECD economies, perhaps reflecting the effect of the aspiration of many EU countries to secure EMU participation. Nonetheless, such a process of fiscal convergence for EU countries has not brought any substantial productivity improvements. Fiscal

[9] See Kleis and Moessinger, 2016 and Amo-Yartey et al, 2012 for an overview of the criteria used to define fiscal consolidation episodes.

loosening is the common characteristic of most OECD countries in the next decade. This primarily reflects the asymmetrical operation of fiscal policies over the business cycle, whereby governments have been more prone to stimulating economies in downswings than to restricting economic growth in upswings via tightening budget balances. Thus, favourable macroeconomic developments in the beginning of the 2000s were, on average, not accompanied by a tighter fiscal stance (i.e. d*capb* is negative for almost all countries), which seems to be beneficial for productivity. The enormous fiscal stimulus and bank bail-outs programmes in response to the 2008 economic crisis justifies the fiscal stance portrayed in the last graph of Figure 2, which mainly shows governments' efforts to bring fiscal deficit figures back under control. Although these illustrations are crude, they portray a strong element of heterogeneity in the TFP- austerity nexus. Yet to be analysed more systemically in the following sections, the consideration that all countries converge to the same long-run equilibrium relationship between TFP and fiscal consolidation seems to be misleading even from a simple and descriptive identification of the data.

4. Empirical strategy

4.1 A panel vector auto-regression (PVAR) model

Our first econometric specification is a Panel Vector Autoregressive (PVAR) model (Holtz-Eakin et al, 1988) similar to the specification used in the expansionary austerity literature (Jordà and Taylor, 2015; Guajardo et al, 2014). This set-up can also be used as a means of comparison between our findings and results for the effects of fiscal consolidation on demand side variables such as consumption and investment. The nature of a PVAR estimation primarily focuses on short-run dynamics between fiscal consolidation episodes and TFP while it allows for unobserved individual heterogeneity. The next section develops an econometric approach that treats the relationship between productivity and fiscal adjustments within the framework of an error correction model where long-run effects between TFP and fiscal policy are established. The PVAR model is specified as follows:

$$B_0 Z_t = \sum_{h=1}^{H} B_h Z_{t-h} + \upsilon_{it} \quad (1)$$

$Z = [\Delta tfp, FCE]$ is a vector of endogenous variables, where *tfp* is Total Factor Productivity, *FCE* is fiscal consolidation episodes and Δ is the difference operator. Index *h* gives the order of lags in the PVAR. Equation (1) is augmented with an error term υ_{it} that has zero mean and constant variance. As explained later, *FCE* is defined in three ways to capture different intensities in the implementation of fiscal consolidation attempts. In formulation (1), the first variable is assumed to be Δtfp. To estimate (1) we rely on the orthogonalisation of impulse response functions (IRF). The IRF describes the reaction of one variable to the innovations of another variable while all other forces of the system are held constant. A common issue in the PVAR is that diagonal elements of the residual covariance matrix are not constant. To make the covariance matrix orthogonal, we use the convention of allocating any correlation between the residuals of any two elements to the variable that comes first in ordering.[10] The identifying assumption for doing so is that variables come first in the ordering affect following variables contemporaneously. This is to say that current shocks in Δtfp have an effect on current fiscal policy, while fiscal policy actions impact on Δtfp with a lag. Intuitively, this assumption is plausible for two reasons, first, the government budget is determined once in a year so any decisions that impact on economic activities will be effectively implemented in the forthcoming year. On the other hand, it is common for a government to respond to a productivity shock within the same year.

The estimation of PVAR presupposes that the underlying process is the same for each country (the cross-sectional unit). This is unlikely to be the case in a panel data set, so the model controls for heterogeneity by including country fixed effects. As fixed effects are correlated with regressors due to lags of Δtfp_{it} on the right hand side of the equation, we apply the forward mean differencing, also known as the Helmet procedure (Arellano and Bover, 1995). This procedure removes only the forward means of all available future observations for each country. Since past realizations are not included in this transformation, the orthogonality condition holds, so lag values of the untransformed level variables can still be used as

[10] To identify the system, we use the Choleski decomposition of variance-covariance matrix of residuals, which transforms the VAR into a recursive one (Hamilton, 1994).

instruments for the transformed endogenous variables. Time fixed effects ν_t in (1) are eliminated by subtracting from each variable the year sample mean (Love and Zicchino, 2006). After these transformations, we obtain coefficients for the elements of matrix *B* in (1) using a system GMM.

The variable of interest is *FCE*, which is defined in three different ways. Although, all three definitions capture large consolidation attempts, the first two refer to cumulative effects over a number of years while the third one identifies improvements in a single year and is widely regarded as an episode of severe austerity. Precisely, *FCE1* takes the value one if country *i* has achieved cumulatively a d*capb*>1% for two consecutive years with at least 0.5% in the first year and zero otherwise, (Ahrend et al. 2006); *FCE2* takes the value one if country *i* has achieved cumulatively a d*capb*>1.5% for three years with a *Δ.capb* no less than 0.5% for any of the years and zero otherwise (European Commission, 2007 and Barrios et al., 2010); *FCE3* takes the value one if country *i* has achieved a d*capb* >1.5 in year *t* and zero otherwise (Alesina and Perotti, 1997; Alesina and Ardagna, 2010; Hernández de Cos and Moral-Benito, 2013). Appendix D2 displays the number of fiscal consolidation episodes for each country and which years have taken place using definition *FC3*.

PVAR results are presented in the form of IRFs.[11] Within this context, IRFs show the evolution of current TFP after episodes of fiscal consolidation while all other shocks in the system are held equal to zero. IRFs are specified within 95% confidence intervals that are drawn from 200 Monte Carlo simulation iterations. Figure 3 displays three IRFs, one for each definition of fiscal consolidation episode (*FCE*). These estimates suggest a negative impact of fiscal consolidation on TFP with the effect to last from one to two years depending on the *FCE* definition considered. For *FCE1*, the impact of the episode is significant for t+1 while it is eliminated in years t+2 and t+3. The size of this effect is 0.8 percent. When, fiscal consolidation over a 3 years period of 3 years is considered, *FCE2*, the effect lasts for 2 years and the cumulative decrease in TFP is equal to 1.2 percent. The strongest effect on TFP from a *FCE* is found with *FCE3* whose duration is for two years and decreases TFP by 1.7 percent. Overall, PVAR estimates indicate that the short-run effects of fiscal

[11] The full set of estimates alongside with coefficients from selection criteria are displayed in the Appendix B.

consolidation on TFP are present and last for about two years. The size of this impact is within the range of 0.10 to 0.17 percent, depending how *FCE*s are measured and is somehow smaller than figures documented in the expansionary austerity literature (Guajardo et al. 2014) for an array of domestic demand variables. More crucially, we confirm the existence of contractionary short-run effects of austerity in productivity while long-run effects might also be existent from the tightening or loosening of fiscal policy, these will be more accurately identified in the next section.

4.1.1 Estimations for high debt-low debt countries

In addition to the full sample analysis, we also estimate PVARs for a group of high and low debt countries. The rationale for this exercise is to explore whether the benefits of productivity enhancing austerity discussed above are more relevant for countries with substantial burden of public debt. This is to say that the credibility scenario of productivity-enhancing austerity holds when the country exceeds a critical threshold of debt and needs to call for some type of fiscal adjustment in order to maintain a stable private business environment with low inflation and default risks. In an analogous way, countries with low level of public debt are likely to be harmed disproportionately from austerity as this can be an unnecessary policy action that can potentially harm the productive capacity of the economy. To conduct the estimation for countries with different levels of debt, we use as threshold point the sample median value of debt-to-GDP ratio to define "High Debt" and "Low Debt" countries (Eberhardt and Presbitero, 2015).[12]

Graphs from IRFs and 5% error bands for the three alternative definitions of FCE are shown in Figure 4. A table with full estimated coefficients is displayed in the Appendix B4. TFP responds negatively to a FCE in low debt countries both in estimated coefficients and impulse responses. The effect in high debt countries is insignificant and this pattern persists regardless of the definition of FCE. In estimating the PVAR, the optimal number of lags is specified at two with the highest cumulative coefficient to be 0.34 for low debt countries when *FCE2* is used (i.e. a d*capb*>1.5% for

[12] The sample median is 60.2%, very close to the 60% Maastricht rule for the Eurozone countries. Appendix B3 displays the average value of debt-to-GDP ratio over the period 1980-2016 for all countries. Using the "canonical" rule of 90% debt-to-GDP ratio leaves us only with four countries in the "high debt" group, Belgium, Greece, Italy and Japan. With this small number of observations the covariance matrix becomes singular, so it becomes infeasible to estimate a PVAR.

three years).These results suggest that austerity in the form of fiscal consolidation has larger effects on TFP in low debt countries.

4.2 An error correction model (ECM)

To understand how changes in the size of fiscal consolidation impact on TFP, we use a specification that models the effect of CAPB on TFP instead of the binary variable of fiscal consolidation episodes. Given the importance of time series properties in panel data, we adopt an Error Correction Model (ECM) to: (i) distinguish between long run and short run behaviour (ii) determine the speed of adjustment of the economy towards long run equilibrium and (iii) test for cointegration in the element included in the error correction term. The main equation of interest is a log-linear specification of TFP as follows:

$$tfp_{it} = \alpha_0 + \alpha_B \Lambda_{it} + \mathbf{x}'_{it}\boldsymbol{\alpha}_{\mathbf{X}} + u_{it} \quad (1)$$

tfp is a measure of total factor productivity in country *i* and year *t*. Variable Λ stands for *capb* (cyclically adjustment primary balance), **x** is a vector of other covariates that drive *tfp* and $\boldsymbol{\alpha}$ is a vector of parameters to be estimated. The ECM representation of (1) is written as:

$$\mathrm{D}tfp_{it} = \varphi_i(tfp_{it-1} - \alpha_{\mathrm{L}}\mathrm{L}_{it-1} - \mathbf{x}'_{it-1}\boldsymbol{\alpha}_{\mathbf{x}}) + \delta_{\mathrm{L}}\mathrm{DL}_{it} + \delta_{\mathbf{x}}\mathrm{D}\mathbf{x}_{it} + u_{it} \quad (2)$$

Parameter φ_i shows the error correcting speed of adjustment towards long-run equilibrium, parameters α_{L} and $\boldsymbol{\alpha}_{\mathbf{x}}$ represent the long-run equilibrium relationship between *capb* and variables in **x** with *tfp*, respectively. Parameters δ_{Λ} and $\delta_{\mathbf{x}}$ represent short-run coefficients between *tfp* and first differences of the right-hand side regressors. After re-parameterising (2), we can get:

$$\mathrm{D}tfp_{it} = \pi_0 + \pi_i^{EC}tfp_{it-1} + \pi_{\mathrm{L}}\mathrm{L}_{it-1} + \boldsymbol{\pi}_{\mathbf{x}}\mathbf{x}'_{it-1} + \delta_{\mathrm{L}}\mathrm{DL}_{it} + \delta_{\mathbf{x}}\mathrm{D}\mathbf{x}'_{it} + u_{it} \quad (3)$$

From the level terms, we restore long-run elasticities as: $\alpha_{\mathrm{L}} = -\frac{\pi_{\mathrm{L}}}{\pi_i^{EC}}$ and $\boldsymbol{\alpha}_{\mathbf{x}} = -\frac{\boldsymbol{\pi}_{\mathbf{x}}}{\pi_i^{EC}}$ while elasticities of short-run dynamics are directly interpreted from δ_{Λ} and $\delta_{\mathbf{x}}$. Regarding variables in **x**, we draw evidence from the most recent literature (Mc Morrow et al. 2010; Bjørnskov, C. and Méon, 2015) and include R&D stock as a share

of GDP (R), trade openness (OPEN) measured as a share of GDP and interest rate of government bonds (*i*). [13]

To estimate (3), we employ two different dynamic panel data techniques; namely, the Pooled Mean Group (PMG) estimator of Pesaran et al. (1999) and the Dynamic Ordinary Least Squares (DOLS) estimator of Kao and Chiang (2000). The PMG is a maximum likelihood (ML) estimator of an autoregressive distributed lag (ARDL) specification allowing for short-run dynamic heterogeneity of the adjustment process (Demetriades and Law 2006) that is short-run coefficients are allowed to vary across countries while the speed of adjustment and long-run coefficients are restricted to be the same across countries,. The DOLS estimator is a fully parametric method for estimating the long-run relationship given that the variables included in the specification are cointegrated.[14]

4.2.1 Panel unit root and panel cointegration tests

Before estimating the cointegrating relationship (3) we test for the order of integration of the variables included in the long-run equation using the panel unit root tests of Im et al. (2003) and the Maddala and Wu (1999).[15] As shown in Table 1, tests fail to reject the null hypothesis of non-stationarity (otherwise the existence of a unit root) in all series except from CAPB.[16]Accordingly, all variables in first differences become stationary I(0) and first-order integrated I(1).

The next test is to establish whether cointegration is present among the variables. Two specifications are shown denoted as Models 1a and 1b using the two alternative measures of CAPB. Table 2 reports the panel cointegration tests of Kao (1999), Pedroni (1999) and the Johansen-Fisher (Maddala and Wu, 1999). The

[13] R&D stock is calculated using the perpetual inventory method. R&D investment data in 2010 USD refer to total Business R&D (BERD) and they are taken from OECD (Main Science and Technology Indicators). Trade openness is the ratio of imports and exports over GDP (OECD- Economic Outlook). Interest rate is the long-term interest on government bonds (OECD-Economic outlook). Human capital is the human capital index based on years of schooling and returns to education (PWT9). Appendix D1 shows summary statistics.

[14] See appendix C1 for a full representation of the DOLS specification.

[15] These tests estimate a separate ADF regression for each individual cross-section to allow for separate unit root processes (the known between dimension). Each of the tests is performed assuming an intercept, or an intercept and a linear trend.

[16] As a robustness check, we use and report estimates from two alternative definitions of CAPB. The superscript O refers to our own calculations for deriving CAPB broadly following the European Commission methodology and E refers to the CAPB measure directly taken from the OECD Economic Outlook series (for details see Appendix D).

Pedroni test refers to the null hypothesis of no cointegration with alternative hypotheses allowing for heterogeneity among countries. The first four of the Pedroni tests are within-group statistics (panel statistics) and compute the unit root tests of the residuals pooling the autoregressive coefficients across countries. The between-group statistics compute the tests by allowing the first-order autoregressive term to vary across countries and then averaging individual estimates across countries. With the exception of the v-statistic, panel and group statistics reject the null hypothesis of no cointegration for both specifications. Similar results are produced from Kao[17] and Johansen-Fisher tests. The persistence in rejecting the null hypothesis suggests the existence of a homogeneous relationship that is in line with the use of the PMG estimator. A similar result is also indicated from the Kao test, which assumes panel homogeneity. Consequently, there is strong evidence that TFP, CAPB and control variables across the 26 countries in both specifications are cointegrated and two long-run homogeneous relationships could possibly be derived.

4.2.2 Results from dynamic panel estimators

Table 3 presents estimates from PMG and DOLS using two alternative measures of $CAPB^{O}$ and $CAPB^{E}$. In the dynamic specification of the PMG estimator, the short-run error correction coefficient is negative and significant indicating a relatively fast adjustment to equilibrium. In a year about 40% has reverted back to the long-run cointegrating relationship while full equilibrium is attained in almost two years. Error correction is an important feature of the TFP-CAPB relationship expressed uniformly across the 26 countries of the sample. A general observation is that the estimates for alternative measures of CAPB are similar implying that our results are not driven from any methodological issue in the way the cyclical adjusted primary balance is calculated. Our results highlight a strong long-run relationship between TFP and fiscal balance for OECD countries. Fiscal tightening has a negative and significant effect on TFP with the magnitude of this coefficient being stronger when the OECD Economic Outlook definition of CAPB is used. The size of all coefficients is larger in the DOLS estimates with *openness* being the determinant

[17] The Kao test imposes homogeneity on cointegrating vectors. It is essentially a generalization of the DF (Dickey-Fuller) and the ADF (Augmented Dickey Fuller) tests.

with the strongest impact on TFP. The remaining coefficients, are statistically significant with the expected signs. These results suggest that in statistical terms, consolidation generates harmful effects to long run productivity. Nonetheless the size of this effect as it is shown by the CAPB coefficient is smaller from the benefits generated by the traditional productivity drivers of R&D and trade openness. This finding is related to the nature of fiscal action whose adverse effects on TFP occur primarily though negative spillovers due to underinvestment in public capital assets. To ensure that our estimates are robust to the inclusion of additional TFP determinants, we add human capital as a regressor and replicate the estimations in specification (3). The estimate of CAPB remains qualitatively unchanged between the two definitions of CAPB and estimation methods. The size of the coefficient is almost the same under both definitions of CAPB and remains highly significant in statistical terms in all cases. The only distinct change in estimates of column (3) and (4) is that the coefficient of *i* is now insignificant in the PMG estimator.

Our main conclusion from the dynamic panel estimators is that the data present evidence of a robust negative long-run relationship between discretionary fiscal policy, as measured by the CAPB, and TFP, suggesting that contractionary fiscal policy hurts productivity in a lasting fashion. This finding could prove useful is several contexts, as for instance it could help explain recent evidence contrasting the post-2007/8 crisis adjustment in the Eurozone and the US. The slump in real activity in the post-2009 period was markedly more protracted in the Eurozone and this, according to (Kollmann et al, 2016), reflects to a large extent precisely negative shocks to TFP growth, which were not present in the US. Our results would provide direct support to this view and in fact attribute the lower productivity growth in the Eurozone at least partly to differential fiscal policy, as between 2009 and 2016 the CAPB stood on average at 0.2% of potential GDP in the Eurozone, compared to -3.7% in the US.[18] As has already been discussed in Section 2, austerity is more likely to impede productivity thought the supply side of the economy, namely through limiting public spending on drivers of TFP like public infrastructure, education and R&D. Empirically verifying more specifically this mechanism is a promising path for

[18] The CAPB measure used is derived from the OECD Economic Outlook and corresponds to the $CAPB^{E}$ variable in Tables 1 and 3 in the paper.

future research and we take the first step into this path by further examining in the next section whether revenue- or expenditure-based fiscal consolidation is more damaging to the productive capacity of the economy. As already mentioned, the expansionary austerity thesis argues in favour of spending-based consolidations, but the line of reasoning presented here would point to exactly the opposite conclusion.

4.2.3 Tax versus spending driven consolidation

In this last section, we extend our analysis by decomposing fiscal consolidation into spending cuts and tax hikes. For this exercise, we use the data set of Devries et al. (2011) that reports policy actions for fiscal consolidation of 17 OECD countries over a shorter time span and smaller country coverage than those used so far for previous estimates. We replicate the PMG and DOLS estimates of Table 3 using spending cuts and tax hikes (both expressed as shares to GDP), separately. We first report in column (1) of Table 4 estimates from a total consolidation variable as reported in Devries et al. (2011). Columns (1) and (3) in Table 4 can be viewed as an additional robustness check of estimates shown in Table 3, nonetheless these estimates are not directly comparable as the size of the sample is now smaller both in time dimension and countries coverage. The *consolidation* variable is insignificant in the PMG estimator while it remains negative and statistically significant in DOLS. The size of estimates of R&D and *openness* are qualitatively similar to the estimates reported in Table 3. Columns (2) and (4) indicate that tax hike driven consolidation has a positive effect on TFP while the opposite is true for spending cuts. Estimated coefficients do not change substantially between PMG and DOLS. This pattern of results indicates that spending driven consolidation is harmful for TFP while tax driven austerity appears to be beneficial for TFP. Such a result is rather intriguing as it points towards two crucial implications, first, the type of consolidation matters and second, arguments in favour of productivity enhancing austerity mainly work through taxation hikes. This is to say that any uncertainty associated with expansionary fiscal policy can be more effectively corrected with an increase in taxes rather than spending cuts. Our findings do not comply with the common wisdom that government spending is essentially unproductive (transfers and social benefits etc.); on the contrary, government consumption plays a central role in shaping national

productive capacity in terms of fixed assets that are more likely complementary to private investment. The result that spending driven consolidation has a negative impact on TFP also suggests that government is in charge of sectors such as education, health and justice whose underfunding can have crucial negative consequences in the long run.

5. Concluding remarks

The present paper is the first to attempt to evaluate the role of fiscal consolidation on productivity. The existing literature is mainly on the role of short-run effects without considering if austerity has long-run effects on economic activity through the supply side of the economy. The main goal of our paper is to shed light on this rather unexplored area of the expansionary austerity literature agenda. Our findings point to the presence of both short-run and long-run effects of fiscal consolidation on TFP. The negative impact of fiscal consolidation episodes lasts for about two years and its negative effect is disproportionately more damaging for the TFP of low debt countries, where probably issues of debt sustainability affect negatively private expectations. The long-run effect is investigated with the framework of an ECM and shows that the effect of fiscal consolidation on TFP is negative in the long-run with a relatively small size relative to other traditional TFP drivers but not negligible in any case under statistical terms. Our findings thus highlight yet another channel through which austerity impairs long-run growth prospects, namely via its impact on the productivity potential of the economy.

This has serious policy implications not only with regard to the validity of the expansionary fiscal contraction thesis, but also in the context of the debt-sustainability debate, where austerity can prove self-defeating. On a more general front, our findings could also contribute to the currently heated debate on better understanding hysteresis mechanisms, or what Stiglitz (2015) called the missing "dark matter", following economic crises like the global recent one which affect economies' productive capacity (Ball, 2014). Having established contractionary fiscal policy as a one of the long-run determinants of such capacity highlights an additional cost of austerity and calls for a more in-depth analysis of its design on the policy front.

Our results also cast doubt on the claim regarding the superiority of spending-based fiscal consolidations, which has been central in the policy debate on the design of austerity programmes worldwide. A crucial finding of our analysis is that tax based austerity is more appropriate for TFP while spending driven consolidation undermines capacity due to the importance of government spending in shaping productive capital. Public expenditure on infrastructure projects, technology, innovation, education and health builds the physical, human and social capital that enhances the productive capacity of the economy and such expenditure often bears a large share of the burden of fiscal consolidation. Some caveats are in order regarding our analysis. First we need a more thorough classification of what really represents productive government spending. This requires the construction of a CAPB measure that will explicitly distinguish between productive and non-productive government spending. Additionally, our analysis does not investigate whether non-linearities and asymmetries are present in the sample. Although we have split our sample into low and high debt countries, it remains of interest to explore whether the TFP-fiscal consolidation nexus changes above or below critical thresholds of austerity. Within a panel of heterogeneous countries it will be also of relevance to identify country specific thresholds in the TFP austerity nexus. All these matters call for further research on the topic.

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Appendices

A. TFP measurement

We consider the following aggregate production function with parameter *A* to represent Hicks neutral technical change:

$$Y_{it} = A_{it} L_{it}^{a_L} K_{it}^{1-a_L} \qquad \text{(A1)}$$

Y is value added, *L* is labour and *K* is capital stock; *i* and *t* index country and year, respectively. The share of labour to value added is denoted by $a_L < 1$. Labour input is measured in hours worked per employee in the total economy (OECD, Economic Outlook) and capital stock is constructed with the perpetual inventory method as follows: $K_{it} = K_{it-1} - \delta K_{it-1} + I_{it-1}$, where δ is the physical depreciation rate defined at a constant rate of 10% for all countries. *I* is investment in Gross Fixed Capital Formation (OECD, Economic Outlook). We initiate the series of capital stock from the following steady state condition: $K_{it=0} \equiv \frac{I_{it=0}}{\overline{g}_i + \delta}$, where $\overline{g}$ is the sample mean of investment growth rate for each country. Value added and investment are deflated using GDP and GFCF deflators (2010=100) (OECD, Economic Outlook). Labour share is the ratio of real wages to real GDP. Wages are deflated using the consumer price index (CPI). To make values comparable across countries, we express all data into PPP constant USD (2010=100). To measure TFP, the empirical counterpart of *A*, we use the Tornqvist index number (Caves et al., 1982), which is superlative as its components can be derived from an underlying translog production function. Accordingly, output and input units in each country are expressed relative to a hypothetical reference point. After taking logs of (A1) and re-arranging we get:

$$TFP_{it} = \left(\log Y_{it} - \log \overline{Y}\right) - \tilde{a}_{it}^{L}\left(\log L_{it} - \log \overline{L}\right) - (1 - \tilde{a}_{it}^{L})\left(\log K_{it} - \log \overline{K}\right) \qquad \text{(A2)}$$

The hypothetical points for *Y*, *L* and *K* are denoted with a bar and defined as sample geometric means of each variable. Analogously, we express the adjusted labor shares as: $\tilde{a}_{it} = \frac{a_{it} + \overline{a}}{2}$ with the waved bar above a to represent the sample arithmetic mean.

B. Panel var (PVAR) estimations

Table B1: Panel VAR estimates of Δ*tfp* on measures of fiscal consolidation, 26 countries, 1980-2016

	Response of Δtfp_t to:		
	(1)	(2)	(3)
Δtfp_{t-1}	0.254***	0.235***	0.235***
	(0.08)	(0.08)	(0.08)
Δtfp_{t-2}	0.029	0.025	0.032
	(0.06)	(0.05)	(0.06)
Δtfp_{t-3}	0.054	0.060	0.050
	(0.06)	(0.05)	(0.05)
$FCE1_{t-1}$	-0.010		
	(0.01)		
$FCE1_{t-2}$	-0.027***		
	(0.01)		
$FCE1_{t-3}$	-0.003		
	(0.01)		
$FCE2_{t-1}$		-0.023***	
		(0.01)	
$FCE2_{t-2}$		0.004	
		(0.01)	
$FCE2_{t-3}$		-0.013*	
		(0.01)	
$FCE3_{t-1}$			-0.019*
			(0.01)
$FCE3_{t-2}$			-0.017
			(0.01)
$FCE3_{t-3}$			-0.011
			(0.01)
Sum	0.03**	0.03***	0.04**
	(0.01)	(0.01)	(0.02)
Observations	737	778	778
Number of countries	26	26	26
Tmin	1984	1984	1984
Tmax	2015	2015	2015

Standard errors in parentheses are clustered by country with * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Cross-country heterogeneity is removed using forward orthogonal transformation. Endogenous variables are first transformed using the forward orthogonal deviation, then they are instrumented with lags in (t-1) and (t-2) of the untransformed regressors. The estimation also controls for temporal common time dependence expressing each variable as deviation from its cross-sectional mean. Sum is the cumulative effect of fiscal consolidation coefficients over the three years period, standard errors of cumulative estimates are computed with the delta method.

Table B1 shows results from the following PVAR model:

$$\Delta tfp_{it} = \rho_i + \nu_t + \sum_{t-h}^{H} \beta_{1t-h} \Delta tfp_{it-h} + \sum_{t-h}^{H} \beta_{2t-h} FC_{it-h} + \upsilon_{it} \text{ with } h \geq 1 \quad \text{(B1)}$$

using a system GMM estimator. Parameter ρ_i controls for country heterogeneity and ν_t for time-wise macroeconomic effects. The optimal number of lags is chosen following the method of Andrews and Lu (2001) for method and moment model selection analogous to the standard maximum likelihood criteria of Bayesian and Akaike. Accordingly, a model with three lags in (B1) minimise both BIC and AIC.

Table B2: lag selection criteria

Numbers of lags	MBIC	MAIC
	FCE1	
1	-25.48344	10.75191
2	-43.86729	10.48574
3	-67.34058	5.130124
4	-5.628352	12.48932
	FCE2	
1	-31.84603	4.854373
2	-52.55787	8.248734
3	-65.15207	2.492728
4	-11.52538	6.824821
	FCE3	
1	-31.7996	4.900799
2	-55.57539	-.524787
3	-70.48421	2.916594
4	-12.65899	5.691207

Notes: MBIC Moment Bayesian selection and MAIC Akaike selection criterion following the method of Andrews and Lu(2001)

Table B3: Average values of debt-to-GDP ratio, 1980-2016, sample median: 60.2%

Country	Mean	Group
Austria	63.74	High
Belgium	109.74	High
Czech Republic	28.17	Low
Denmark	54.82	Low
Finland	37.15	Low
France	56.53	Low
Germany	62.79	High
Greece	98.02	High
Hungary	68.24	High
Iceland	56.11	Low
Ireland	73.05	High
Italy	100.76	High
Japan	135.25	High
Netherlands	61.36	High
Norway	36.73	Low
Poland	46.47	Low
Portugal	67.68	High
Spain	52.98	Low
Sweden	50.59	Low
United Kingdom	49.45	Low
United States	68.59	High
	65.63	

Table B4: Panel VAR Estimates of Δ*tfp* and measures of fiscal consolidation by high and low debt, 26 countries, 1980-2016

	High Debt	Low Debt	High Debt	Low Debt	High Debt	Low Debt
	Response of Δtfp_t to:					
	(1)		(2)		(3)	
Δtfp_{t-1}	0.322***	0.201***	0.294**	0.138**	0.353***	0.194***
	(0.12)	(0.04)	(0.12)	(0.06)	(0.12)	(0.05)
Δtfp_{t-2}	0.171**	0.016	0.105	-0.065	0.163**	-0.019
	(0.09)	(0.05)	(0.08)	(0.04)	(0.08)	(0.04)
$FC1_{t-1}$	-0.013	-0.024***				
	(0.01)	(0.01)				
$FCE1_{t-2}$	-0.001	0.009				
	(0.01)	(0.01)				
$FCE2_{t-1}$			-0.005	-0.014		
			(0.01)	(0.01)		
$FCE2_{t-2}$			-0.013	-0.021***		
			(0.01)	(0.01)		
$FCE3_{t-1}$					-0.012	-0.003
					(0.01)	(0.01)
$FCE3_{t-2}$					-0.022	-0.026***
					(0.01)	(0.01)
Sum	0.014	-0.016*	-0.018	-0.34***	-0.033	-0.028**
	(0.013)	(0.008)	(0.016)	(0.01)	(0.02)	(0.01)
Observations	336	468	295	416	317	446
Countries	11	15	11	15	11	15
Tmin	1983	1983	1985	1985	1983	1983
Tmax	2015	2015	2015	2015	2015	2015

Standard errors in parentheses are clustered by country with * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The threshold value for splitting the sample is the median value of debt-to-GDP ratio (63%). Cross-country heterogeneity is removed using forward orthogonal transformation. Endogenous variables are first transformed using the forward orthogonal deviation, then they are instrumented with lags in (t-1) and (t-2) of the untransformed regressors. The estimation also controls for temporal common time dependence expressing each variable as deviation from its cross-sectional mean. Sum is the cumulative effect of FCE coefficients over the two years period, standard errors of cumulative estimates are computed with the delta method.

C. DOLS specification

DOLS takes account of the endogeneity bias that is inherent in static OLS by augmenting specification (1) with leads, lags and contemporaneous values of all regressors. DOLS estimates the following version of (1):

$$tfp_{it} = \alpha_{\mathrm{L}} \mathrm{L}_{it-1} + \mathbf{x}'_{it-1}\boldsymbol{\alpha}_{\mathbf{x}} + \sum_{j=-p_1}^{j=p_2} c_{ij} \mathrm{D}\mathbf{x}_{it+j} + \sum_{j=-p_1}^{j=p_2} c_{ij} \mathrm{DL}_{it+j} + u_{it} \qquad \text{(C1)}$$

where c_{ij} is the coefficient of a lag or a lead of the first differences of the variables.

D. Definition of CAPB and descriptive statistics

Two alternative definitions of cyclical adjustment of government budget balances that determine fiscal consolidation have been used in the estimation of the relationship between TFP and fiscal consolidation. The first, $\mathrm{CAPB}^{\mathrm{E}}$ is obtained from the OECD Economic Outlook No 102 of November 2017 and it is given as a percentage of potential GDP. Data from Economic Outlook of previous years were used to obtain a continuous series. The OECD uses a disaggregated approach with respect to the calculation of the CAPB where it first adjusts individual tax and spending categories for the cycle, and then aggregates the resulting cyclically adjusted items into a CAPB (for details, see OECD, 2018).

The second definition of cyclically adjusted government balances namely $\mathrm{CAPB}^{\mathrm{O}}$ is derived from own calculations and it is based on the European Commission's method using trend GDP from a Hodrick-Prescott filter. The method involves two main steps. In the first step, the output trend is estimated by means of the Hodrick-Prescott filter and the output gap between the trend GDP level and the actual output is calculated. In the second step, cyclical components of budget balances are calculated by applying the output gaps to the marginal rates of change of revenue and expenditure with respect to GDP. More specifically, the cyclical component of the primary balance is obtained by multiplying the output gap with the budgetary sensitivity to GDP (for details, see European Commission, 2017). Budgetary elasticities have been calculated by OECD in "Measuring cyclically adjusted budget balances for OECD countries" by Nathalie Girouard and Christophe Andre in

OECD Economics Department Working Paper No 434, 2005.[19] Finally, the cyclically adjusted budget balances are obtained by deducting the cyclical component from the actual government budget balances.

Table D1: Descriptive statistics

A. Variables in levels					
Variable	Mean	Median	Sd	Min	Max
tfp_t	0.059	-0.380	1.45	-1.93	4.94
$CAPB_t^E$	-0.152	0.101	3.12	-26.12	14.48
$CAPB_t^O$	-0.209	-0.004	4.14	-31.10	14.85
RD_t	7.727	7.191	4.99	0.24	21.73
i_t	6.826	5.610	4.17	-0.07	29.74
$openness_t$	-0.008	-0.015	0.09	-0.44	0.39
HC_t	3.095	3.141	0.39	1.65	3.73

B. Variables in first differences					
Variable	Mean	Median	Sd	Min	Max
Δtfp_{t-1}	-0.003	-0.002	0.09	-0.44	0.68
$\Delta CAPB_t^E$	0.098	0.082	2.04	-18.33	18.05
$\Delta CAPB_t^O$	0.166	0.075	2.55	-17.80	19.69
ΔRD_t	0.164	0.113	0.28	-1.14	2.58
Δi_t	-0.371	-0.295	1.20	-12.45	6.75
$\Delta openness_t$	0.001	-0.000	0.03	-0.16	0.17
ΔHC_t	0.017	0.017	0.01	-0.02	0.06

Notes: We present descriptive statistics for an unbalanced sample of 739 observations on the average for the six variables that have been used shown in A from 26 countries. In B we present descriptive statistics of the transformations of the same variables used in the error correction model with the corresponding lags.

[19] It should be noted that in our calculations we have used the elasticities for the Total Balance choosing not to break down in revenue and expenditure.

Table D2: Consolidation episodes per country according to criterion FCE3

Country	Number of episodes	Year
Australia	4	1986, 1987, 2011, 2013
Austria	6	1984, 1986, 1997, 2001, 2005, 2015
Belgium	2	1993, 2006
Canada	6	1986, 1987, 1995, 1996, 1997, 2012
Czech Republic	4	1999, 2004, 2013, 2016
Denmark	6	1983, 1984, 1986, 2005, 2013, 2014
Finland	7	1981, 1984, 1988, 1994, 1996, 1998, 2000
France	1	1996
Germany	4	1992, 1996, 2000, 2011
Greece	6	2005. 2010, 2011, 2012,2014, 2016
Hungary	7	1996, 1999,2003,2007,2008, 2009, 2012
Iceland	13	1984, 1988, 1990, 1992, 1995, 1999, 2005, 2009, 2010, 2011, 2012, 2014, 2016
Ireland	8	1983, 1984, 1987, 1988, 2003, 2011, 2012, 2013
Italy	8	1982, 1983, 1991, 1992, 1993, 1997, 2007, 2012
Japan	8	1984. 1985, 1997, 1999, 2001, 2004, 2014, 2015
Korea	3	2000, 2004, 2010
Netherlands	6	1983, 1991, 1993, 1996, 2013, 2016
New Zealand	6	1987, 1989, 1991, 2000, 2011, 2012
Norway	2	1983, 1995
Poland	2	2011, 2012
Portugal	10	1983, 1984, 1988, 1992, 2002, 2006, 2011, 2012, 2013, 2015
Spain	5	1992, 1996, 2010, 2012, 2013
Sweden	5	1983, 1986, 1987, 1996, 2010
Switzerland	0	
UK	6	1982, 1998, 2010, 2011, 2013, 2016
US	2	2011, 2013

Note: FCE3 takes the value one if country *i* has achieved a d*capb* >1.5 in year *t* and zero otherwise.

Tables and Figures

Table 1: Panel unit root tests, 1980-2016

Variables in Level				
	IPS		**Fisher ADF**	
	Trend	**Constant**	**Trend**	**Constant**
tfp	-1.732	-0.829	44.82	74.75
	(0.042)*	(0.204)	(0.750)	(0.021)*
$CAPB^O$	-8.434	-10.998	93.85	106.96
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
$CAPB^E$	-2.939	-4.667	76.13	92.30
	(0.001)**	(0.000)**	(0.016)*	(0.001)**
RD	3.048	8.589	38.84	9.39
	(0.999)	(1.000)	(0.912)	(1.000)
i	0.303	0.599	58.48	23.81
	(0.619)	(0.726)	(0.249)	(0.999)
Openness	-0.299	-2.883	50.22	51.49
	(0.382)	(0.002)*	(0.544)	(0.494)
Variables in First Differences				
tfp	-17.85	-19.871	293.03	370.99
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
$CAPB^O$	-27.94	-22.64	328.25	439.32
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
$CAPB^E$	-18.67	-21.07	275.81	367.62
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
RD	-9.51	-9.97	191.20	208.60
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
I	-16.01	-17.83	319.40	418.68
	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Openness	-19.67	-20.64	266.07	92.25
	(0.000)**	(0.000)**	(0.000)**	(0.000)**

Note: IPS is the Im, Pesaran and Shin (2003) test. Under Trend are reported tests with the use of a constant and a trend in calculating IPS and the Fisher tests while under Constant are reported statistics that use only a constant and no trend. ** and * denote the rejection of the null hypothesis of non-stationarity at 1 and 5 percent levels of significance, respectively. Numbers in parentheses are p-values.

Table 2: Panel cointegration tests

Pedroni Tests	**Model 1**		**Model 2**	
H_o:There is no cointegration H_1:Common AR coefficients				
Panel v	-0.743		-1.425	
Panel ρ	1.216		1.967*	
Panel PP	-4.039**		-3.286**	
Panel ADF	-4.144**		-2.646**	
H_1:Idividual AR coefficients				
Group ρ	3.339**		3.798**	
Group PP	-7.592**		-6.989**	
Group ADF	-5.049**		-3.243**	
Kao ADF	-2.228(0.013)		-2.666(0.003)	
Johansen Fisher test	From Trace Test	From max eigen test	From Trace Test	From max eigen test
H_o:No cointegrating vector	303.3(0.000)	209.8(0.000)	315.4(0.000)	235.4(0.000)
H_1:At most 1 cointegrating vector	192.3(0.000)	896.6(0.000)	183.5(0.000)	902.6(0.000)
H_1:At most 2 cointegrating vectors	102.8(0.000)	102.2(0.000)	93.09(0.000)	94.21(0.000)
H_1:At most 3 cointegrating vectors	31.64(0.947)	32.22(0.938)	29.73(0.969)	26.71(0.989)

Notes: * and ** indicate rejection of the null hypothesis of no cointegration at 5 and 1 percent based on the 1.644 and 2.326 critical values, respectively. Numbers in parentheses are p-values. The Kao and Pedroni tests follow the normal distribution while probabilities in the Johansen Fisher test are computed following asymptotically the chi-squared distribution.

Table 3: The determinants of TFP, long-run estimates from PMG and DOLS

	PMG	PMG	DOLS	DOLS
Model 1a				
$CAPB_t^O$	-0.007	-0.008	-0.010	-0.03
	(0.002)***	(0.002)***	(0.006)*	(0.003)***
RD_t	0.073	0.041	0.021	0.09
	(0.006)***	(0.003)***	(0.324)***	(0.13)**
i_t	-0.006	-0.002	-0.019	-0.001
	(0.000)***	(0.02)	(0.003)***	(0.005)
$openness_t$	0.911	0.70	1.863	1.26
	(0.123)***	(0.006)***	(0.298)***	(0.17)***
HC_t		0.69		0.49
		(0.01)***		(0.01)***
Observations	697	722	745	697
R^2			0.12	0.14
Log likelihood	1230	1046		
F test	$2.05*10^{13}$	$1.95*10^{8}$		
Model 1b				
$CAPB_t^E$	-0.015	-0.006	-0.045	-0.009
	(0.003)***	(0.005)***	(0.007)***	(0.004)**
RD_t	0.076	0.019	0.014	0.16
	(0.005)***	(0.007)***	(0.327)***	(0.012)***
i_t	-0.011	-0.002	-0.017	-0.01
	(0.001)***	(0.05)	(0.003)***	(0.07)
$openness_t$	0.962	0.93	1.381	1.17
	(0.088)***	(0.009)***	(0.188)***	(0.16)***
HC_t		0.80		0.13
		(0.002)***		(0.001)***
Observations	682	727	727	697
R^2			0.13	0.15
LL	1215	1052		
F test	$5*10^{12}$	$4*9^{8}$		
Error Correction Coefficient				
Model 1a	-0.409	-0.306		
	(0.075)***	(0.06)**		
Model 1b	-0.396	-0.278		
	(0.064)***	(0.05)**		

Notes: The dependent variable in PMG is *Δtfp* and in DOLS is *tfp.* In PMG*,* estimates refer to long-run elasticities with respect to relevant regressors, short-run coefficients are not reported here but they are available from the authors upon request. Numbers in parentheses are standard errors. The lag order in the PMG is 2 for the dependent variable and 1 for each of the independent variables. Model selection was based on the Schwartz criterion. F-test refers to the null hypothesis that coefficients of all independent variables included are zero *, ** and *** indicate significance at 10, 5 and 1 percent respectively.

Table 4: The determinants of TFP, long-run estimates from PMG and DOLS. historical data of fiscal consolidation, 1980-2009, 17 OECD countries

	PMG	PMG	DOLS	DOLS
main				
consolidation	-0.045		-0.039**	
	(0.14)		(0.02)	
tax		0.811**		0.441***
		(0.36)		(0.04)
spending		-1.133**		-0.251***
		(0.48)		(0.03)
RD	2.512***	3.235*	0.665***	0.675***
	(0.93)	(1.69)	(0.09)	(0.09)
openness	2.682*	0.882	1.561***	1.539***
	(1.38)	(1.58)	(0.20)	(0.20)
i	-0.061	-0.150	-0.023***	-0.026***
	(0.04)	(0.10)	(0.01)	(0.01)
Observations	475	475	416	416
R^2			0.12	0.12
Error Correction Coefficient				
	0.19 (0.085)*	0.12 (0.1)*		

Notes: The dependent variable in PMG is Δ*tfp* and in DOLS is *tfp*. In PMG, estimates refer to long-run elasticities with respect to relevant regressors, short-run coefficients are not reported here but they are available from the authors upon request. Robust standard errors in parentheses clustered by country with * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1: Change in cyclical adjusted primary balance (dcapb), 26 countries 1980-2016

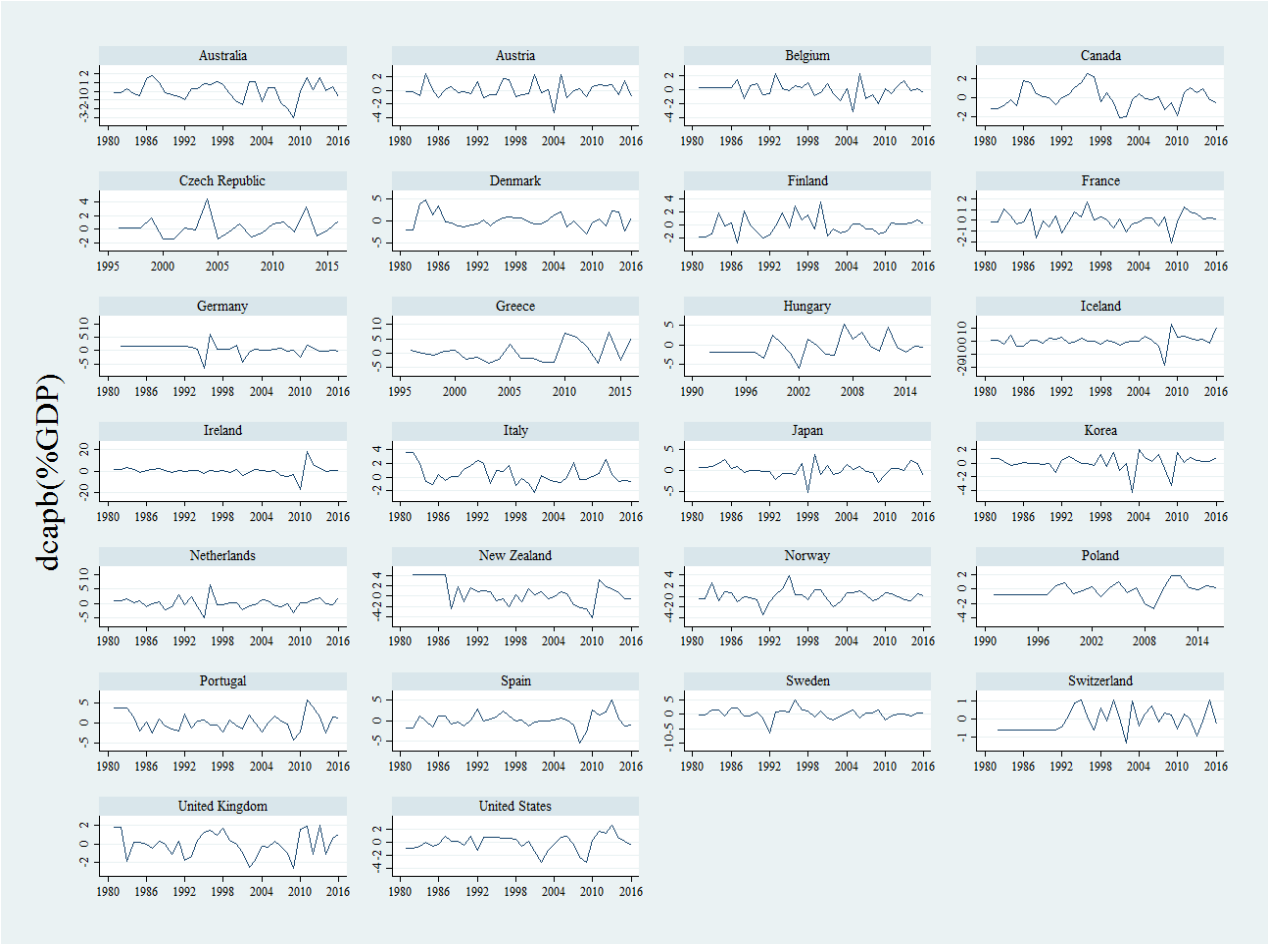
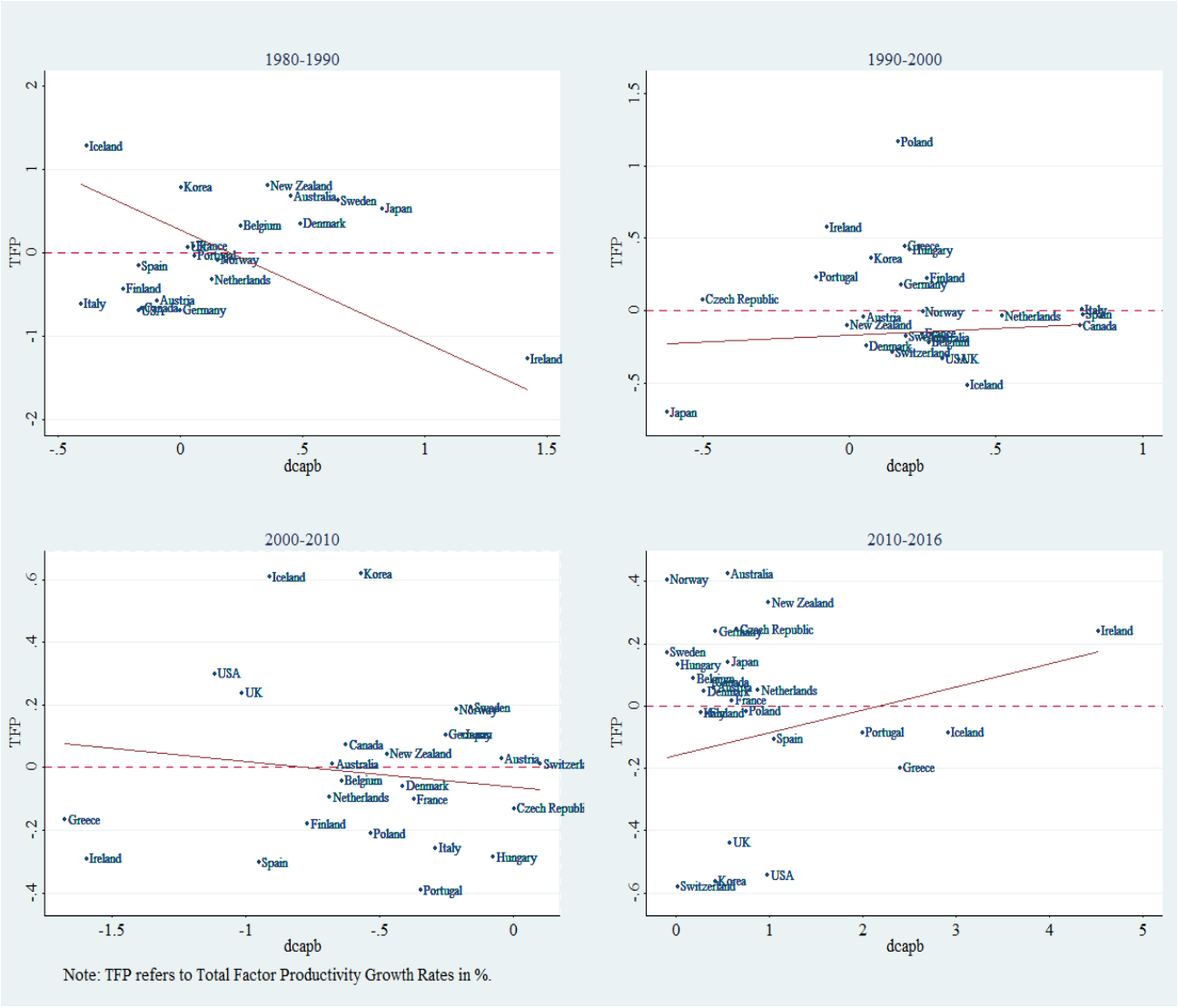


Figure 2: Differences in CAPB (dcapb) Versus TFP for different sub-periods



Note: TFP refers to Total Factor Productivity Growth Rates in %.

Figure 3: Impulse responses for 3 Lags of *Δtfp* and fiscal consolidation episodes-full sample

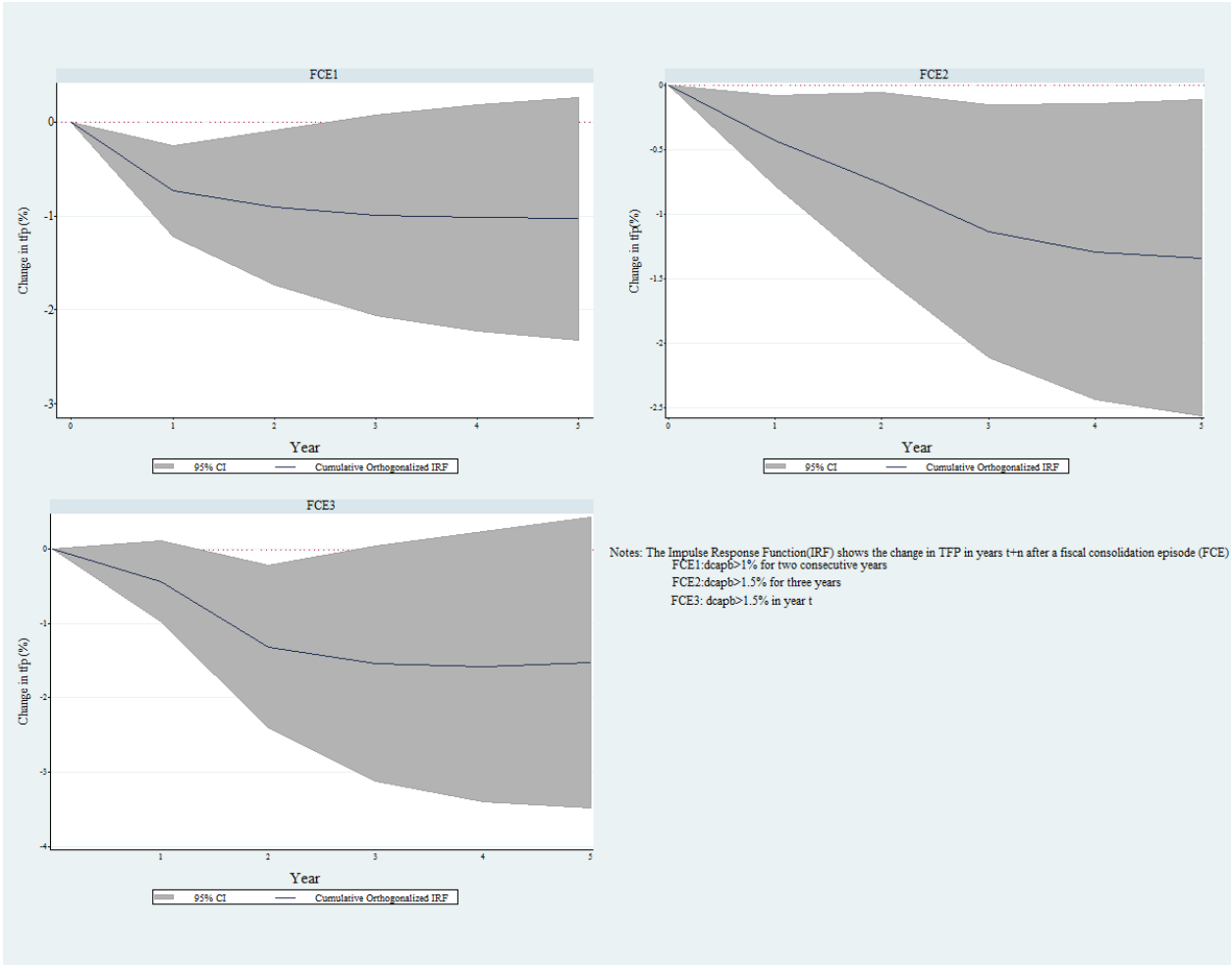
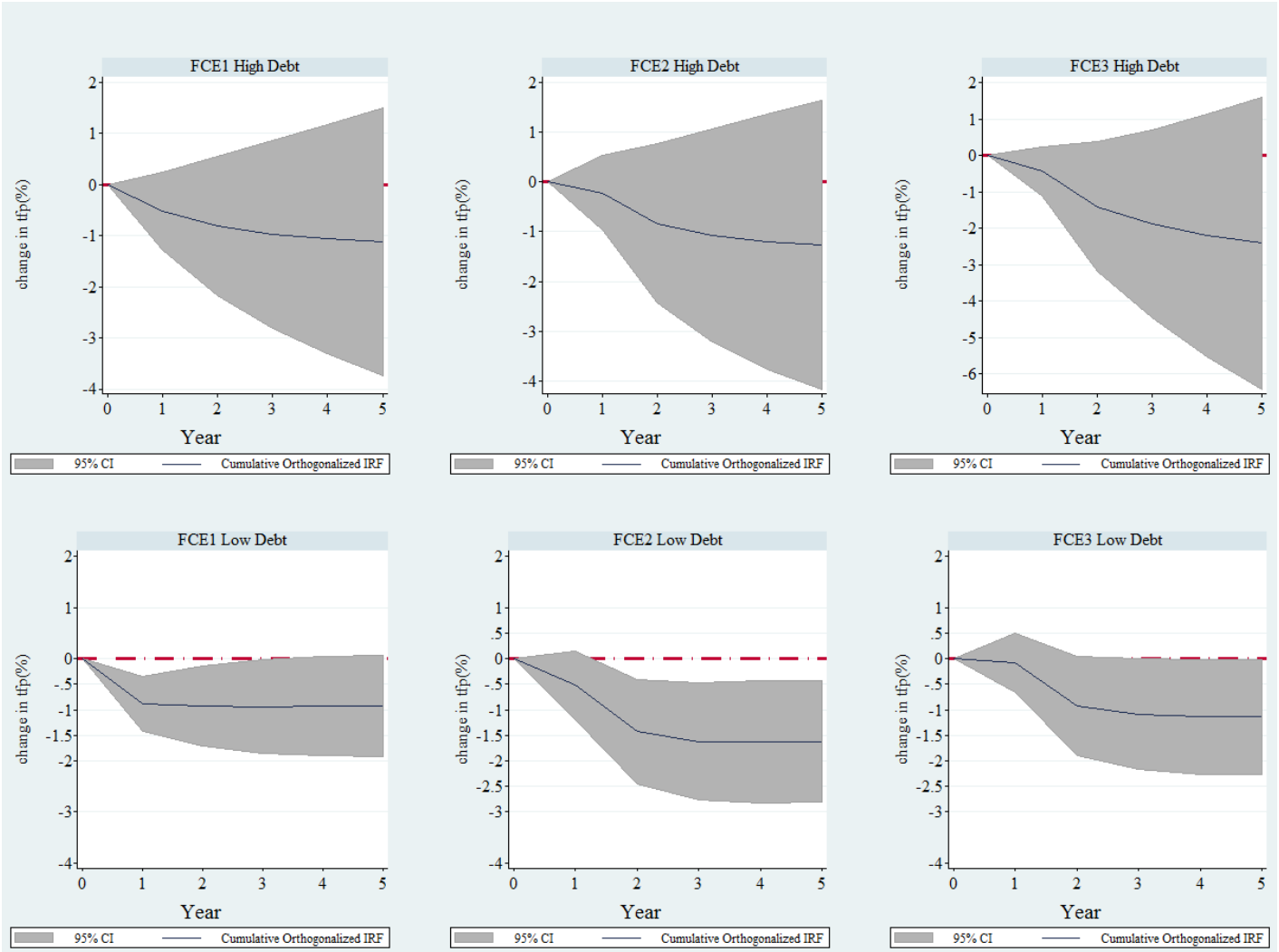


Figure 4: Impulse responses for 2 lags of Δtfp and fiscal consolidation episodes (FCE) for low and high debt countries (Threshold 60.2%)



Note: Debt threshold is defined at 60.2% to GDP(median sample value)

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