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Fiscal policy and TFP in the OECD: A non-stationary Panel Approach

Ruben Schoonackers
Freddy Heylen

Ghent University
Sherppa
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Algemeen secretariaat – Steunpunt beleidsrelevant Onderzoek
Fiscaliteit & Begroting
Voskenslaan 270 – 9000 Gent – België
Tel: 0032 (0)9 248 88 35 – E-mail: vanessa.bombeeck@hogent.be
www.steunpuntfb.be

UNIVERSITEIT GENT

FACULTEIT ECONOMIE
EN BEDRIJFSKUNDE

TWEEKERKENSTRAAT 2
B-9000 GENT
Tel. : 32 - (0)9 – 264.34.61
Fax. : 32 - (0)9 – 264.35.92

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Ruben Schoonackers* and Freddy Heylen†

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Abstract

We analyse the influence of fiscal policy on TFP and per capita output in a panel of OECD countries since 1975. We focus on the effects of government size, government deficits and the composition of taxes and expenditures. Compared to existing studies, our contribution is double. First, we are able to identify both direct and indirect effects of fiscal policy on TFP. The latter stem from the influence of taxes and expenditures on countries' access to and efficient use of the world stock of technology and knowledge. A second contribution is methodological. The role of the worldwide level of technology introduces a common factor (and therefore cross-sectional dependence) in individual countries' TFP. This common factor is unobserved and most likely non-stationary. The existing empirical literature on fiscal policy and growth largely neglects the econometric complications that may arise from cross-sectionally correlated error terms due to unobserved (and potentially non-stationary) common factors. This leads to inconsistent estimates if the unobserved factors are correlated with the explanatory variables and to a spurious regression problem if they are non-stationary. We appropriately deal with these econometric issues by using the Common Correlated Effects Pooled estimator of Pesaran (2006) and Kapetanios et al. (2006). Our main findings are as follows. Through the direct channel, an overall increase in government size reduces TFP and per capita output. Expenditure shifts in favour of productive purposes have strong and robust positive effects on TFP. Shifts in favour of social transfers reduce TFP. Deficit reduction policies raise TFP if they are financed by expenditure cuts. Through the indirect channel, a rise in the corporate tax rate negatively affects a country's access to the worldwide level of technology whereas education expenditures and human capital formation promote this access.

JEL Classification: C31, C33, E62, O38.

Keywords: fiscal policy, total factor productivity, long-run output level, unobserved common factors, panel data

*SHERPPA, Ghent University, Ruben.Schoonackers@UGent.be, http://www.sherppa.be; Postal Address: Tweekerkenstraat 2, 9000 Ghent Belgium; Phone:+3292647881

†SHERPPA, Ghent University, Freddy.Heylen@UGent.be, http://www.sherppa.be

1 Introduction

Rising pressure on the welfare state due to ageing, and the need to bring down government debts and deficits after the recent recession, force all countries to develop effective productivity and growth policies. The importance of higher productivity (per capita output) to face the pension challenge has been demonstrated in various studies (e.g. Docquier and Michel, 1999; Fougère and Mérette, 1999; IMF, 2010). So has the importance of high growth for successful fiscal consolidation (e.g. Alesina and Perotti, 1995 ; Heylen and Everaert, 2000). There is a general agreement in the literature that total factor productivity (TFP) is a very important driver of long-run economic growth. De La Fuente and Doménech (2001) find that TFP differences account for about half of the differences in per capita income across OECD countries. Klenow and Rodríguez-Clare (1997) report an even higher contribution of TFP. Knowing that both the ageing of the labour force and the recent economic crisis may have a negative impact on TFP (Werding, 2008), insight in the way governments can counter this negative impact is very important.

This paper analyses the influence of fiscal policy on TFP and per capita output in a panel of 17 OECD countries for the period 1975-2007. We focus on the effects of government size, government deficits and the composition of taxes and expenditures. A large body of empirical studies have already examined the effects of fiscal policy on economic growth and the long-run output level. However, existing empirical results are far from robust. For example, the sign of the effect of government size and of social security expenditures is ambiguous in the literature. Compared to existing studies our contribution is double. First, we are able to identify both direct and indirect effects of fiscal policy on TFP. The latter stem from the influence of taxes and expenditures on countries' access to and efficient use of the world stock of technology and knowledge (see also Parente and Prescott, 2002). In this sense, our paper is complementary to recent work which has mainly emphasized the role of institutions for a country's access to world technology (e.g. Alfaro et al., 2008; Coe et al., 2009; Faria and Mauro, 2009). A second contribution is methodological. The role of the worldwide level of technology introduces a common factor (and therefore cross-sectional dependence) in individual countries' TFP. This common factor is unobserved and most likely non-stationary. The existing empirical literature on fiscal policy and growth largely neglects the econometric complications that may arise from cross-sectionally correlated error terms due to unobserved (and potentially non-stationary) common factors. This leads to inconsistent estimates if the unobserved factors are correlated with the explanatory variables and to a spurious regression problem if they are non-stationary. We appropriately deal with these econometric issues by using the Common Correlated Effects Pooled estimator of Pesaran (2006) and Kapetanios et al. (2006). Our main findings are quite robust. Through the direct channel, an overall increase in government size reduces TFP and per capita output, except when the increase results from higher productive expenditures (e.g. education, R&D). Expenditure shifts in favour of productive purposes have strong and robust positive effects on TFP. Shifts in favour of social transfers reduce TFP. Deficit reduction policies raise TFP if they are financed by non-productive expenditure cuts. Through the indirect channel, a rise in the corporate tax rate negatively affects a country's access to and efficient use of the worldwide level of technology. Education expenditures and human capital formation promote this access. Our analysis also yields indicative evidence on the role of institutions for countries' access to worldwide technological progress. More open economies and economies with high quality of tertiary education benefit more.

Our paper is organized as follows. In section 2 we model the direct and indirect effects of fiscal policy on TFP. In section 3 we describe our econometric model and methodology. Section 4 contains our empirical analysis, which is split up in a description of the data followed by an examination of the results. Section 5 concludes.

2 Modelling direct and indirect effects of fiscal policy on TFP

In this section we model the potential effects of fiscal policy and its composition on long-run per capita output through TFP. We identify both direct and indirect effects on TFP starting from a production function framework.

The production function for country i at time t is

$$Y_{it} = A_{it} K_{it}^{\beta_1} G_{it}^{\beta_2} \left[h_{it} L_{it} \right]^{1-\beta_1-\beta_2}, \tag{1}$$

with $0 < \beta_1, \beta_2 < 1$ and $\beta_1 + \beta_2 < 1$. Production of real output Y exhibits constant returns to scale in aggregate private capital K, public capital G and labour hL, where L is total employment in persons, and h average hours worked per employed. A represents the level of TFP. It captures the contribution to output of the overall level of efficiency, technology and knowledge. Given our specification of the production function, TFP also incorporates advances in human capital.

In logs and in per capita terms this gives

$$\ln y_{it} = \ln A_{it} + \ln \left[\frac{h_{it} L_{it}}{N_{it}} \right] + \beta_1 \ln \left[\frac{K_{it}}{h_{it} L_{it}} \right] + \beta_2 \ln \left[\frac{G_{it}}{h_{it} L_{it}} \right], \tag{2}$$

where N is population and y real output per capita (Y/N). Per capita output rises in TFP, hours worked per capita, physical capital per hour worked and public capital per hour worked.

The key variable in our model is the level of TFP. Fiscal policy can affect it both directly and indirectly. We call 'direct' the within-country effects of fiscal policy, i.e. the effects on TFP that one would have in a closed economy. 'Indirect' effects run via a country's access to and efficient use of the world stock of technology and knowledge.

In analyzing the direct effects of fiscal policy on TFP, we look at the impact of both government size and the composition of expenditures and taxes.

A large literature has discussed the effects of government size on economic growth (e.g. Agell et al., 1997, 1999; Fölster and Henrekson, 1999, 2001; Wyatt, 2005). The overall evidence is ambiguous, which is not surprising. More important than their size may be the composition of total expenditures and/or taxes. Moreover, the effects of changes in government size may differ depending on the historical level (Barro, 1990).

At the expenditure side, we distinguish productive and unproductive expenditures. The former include mainly government financed R&D, education expenditures and infrastructure investment (see also Kneller et al., 1999; Dhont and Heylen, 2009). There is a clear consensus in the literature that a rise in, or a shift towards, more productive expenditures enhances TFP directly, i.e. productive expenditures raise per capita output and/or growth for given hours worked and input of physical capital. A clear majority of empirical studies find positive effects of public R&D support on overall R&D spending and innovation output (see e.g. Gonzales and Pazo, 2008; and a recent survey by Cox and Gagliardi, 2009). A wealth of studies show positive effects of education expenditures on productivity and growth, both theoretically (e.g. Glomm and Ravikumar, 1997; Docquier and Michel, 1999; Dhont and Heylen, 2009) and empirically (e.g. Nijkamp and Poot, 2004; Blankenau et al., 2007). Some authors emphasize the importance of tertiary education and tertiary education expenditures for innovation and new technology adoption (Krueger and Kumar, 2004; Aghion and Howitt, 2006). In the unproductive expenditure category we find mainly social security expenditures and government consumption net of education. The literature is divided on the impact of social security expenditures. Some studies find a negative effect on TFP, e.g. Hanson and Henrekson (1994) and Arjona et al. (2003). One of the explanations is that high social spending reduces inequality. Since low inequality implies a low return to high-productivity qualifications and effort, social spending may inhibit the efficient use of factors of production. Other studies find positive effects, e.g. Herce et al. (2001) and Zhang and Zhang (2004). Lower inequality may also lead to a more cohesive society. Such societies may be beter able to make difficult political or economic decisions that promote structural adjustment and efficiency. Furthermore, it has been shown that unfunded social security programs may raise productivity by promoting investment in human capital (Zhang, 1995). Overall effects of government consumption on productivity are generally very small. More important is the way in which they are financed (Turnovsky, 2000; Dhont and Heylen, 2009).

At the revenue side of fiscal policy, we look at the impact of corporate, personal and 'other' taxes. The literature shows overall consensus that the impact of corporate and personal taxes on TFP is negative, whereas the effects of other taxes is les clear. High corporate taxes may for example reduce the incentive for firms to invest in innovative activities by reducing their after-tax return (Johansson et al., 2008; Schwellnus and Arnold, 2008). In line with the arguments raised by Arjona et al. (2003) on the effects of (in)equality, high personal taxes may reduce TFP by discouraging work effort. Personal taxes also lower the expected return to investing in schooling, thus resulting in less accumulation of human capital (Bouzahzah et al., 2002; Ferreira and Pesoa, 2007). The latter effect is obvious when it involves taxes on middle aged and older workers. Taxes on labor income of young individuals, however, reduce the opportunity cost of education. They may promote schooling (Heylen and Van de Kerckhove, 2009).

Finally, we analyze the direct effects of government debt and deficit on TFP. We expect a negative relationship. Debt accumulation can be associated with more future taxes, lower future productive expenditures and maybe more uncertainty and instability. Elaborating on the above mentioned arguments, this will hinder improvements in technology and efficiency (Fischer, 1993; Patillo et al., 2004 and Blankenau et al., 2007).

In a closed economy, fiscal policy only has 'direct' effects on TFP. In an open economy, however, additional indirect effects occur. These effects run via a country's access to and efficient use of the worldwide available stock of technology and knowledge. We follow Parente and Prescott (2002) that world technology is commonly available, but that access may differ across countries and over time. Channels of knowledge and technology transfers are multiple: incoming FDI, internet, international publications, import of high technology goods and services etc. Different policies and institutions can either facilitate or put constraints on the availability and efficient use of these channels. Here, we look at the effect of fiscal policy variables on the use of these channels. Our attention goes to the effects of corporate taxes, and education expenditures and human capital formation. These are also most prominent in the literature. High corporate tax rates reduce the after-tax return to investing in a country and may discourage the inflow of FDI, as shown e.g. by Hajkova et al. (2006) and Djankov et al. (2008). Public education expenditures promote the accumulation of human capital. Various studies demonstrate the importance of human capital for the access to and efficient use of the channels of knowledge and technology transfers (e.g. Nelson and Phelps, 1966; Coe et al., 2009; Faria and Mauro, 2009). A country needs to have a certain level of skills in order to be able to succesfully adopt foreign technology, brought by foreign firms for example, or incorporated in imported high technology goods or international publications.

These direct and indirect effects of fiscal policy lead to the following common-factor specification of TFP

$$A_{it} = e^{\gamma_i + \lambda_{it} F_t + \delta GOVD_{it}}, \tag{3}$$

In this equation γ_i denotes an idiosyncratic country technology term (Costantini and Destefanis, 2009). $GOVD_{it}$ assembles fiscal policy variables of country i in period t which influence TFP directly. The worldwide available stock of technology and knowledge is captured by the unobserved common factor F_t. Country i's access to and efficient use of this world technology, λ_{it}, consists of a time-invariant part, λ_{i0} (which may reflect institutions), and a part that depends on policy variables, $\lambda GOVIN_{it}$,

$$\lambda_{it} = \lambda_{i0} + \lambda GOVIN_{it}, \tag{4}$$

where $GOVIN_{it}$ also assembles variables related to fiscal policy. In this paper, we limit our attention to the effects of a change in the corporate tax rate and the effects of education expenditures and investment in human capital. We expect an increase in a country's corporate tax rate to lower its access to world technology (Hajkova et al., 2006; Djankov et al., 2008). A rise in public education expenditures and hence an increase in the educational attainment of the population is expected to have a positive impact on λ_{it}.

We get our final model by substituting equations (3) and (4) into (2)

$$\begin{aligned}\ln y_{it} =& \gamma_i + \lambda_{i0} F_t + \lambda GOVIN_{it} F_t + \delta GOVD_{it} + \ln\left[\frac{h_{it}L_{it}}{N_{it}}\right] + \beta_1 \ln\left[\frac{K_{it}}{h_{it}L_{it}}\right] \\ &+ \beta_2 \ln\left[\frac{G_{it}}{h_{it}L_{it}}\right].\end{aligned} \tag{5}$$

3 Econometric model and methodology

Starting from (5), we will estimate the following model:

$$Z_{it} = \gamma_i + \lambda_{i0} F_t + \lambda GOVIN_{it} F_t + \delta GOVD_{it} + \beta' X_{it} + \varepsilon_{it}, \tag{6}$$

where

$$Z_{it} = \left[\ln y_{it} - \ln\left[\frac{h_{it}L_{it}}{N_{it}}\right]\right], \beta = \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix}$$

and

$$X_{it} = \begin{bmatrix} \ln\left[\frac{K_{it}}{h_{it}L_{it}}\right] \\ \ln\left[\frac{G_{it}}{h_{it}L_{it}}\right] \end{bmatrix}.$$

In (6) the role of the world stock of technology and knowledge (F_t) introduces a common factor (and therefore cross-sectional dependence) in individual countries' TFP. This common factor is unobserved. Neglecting it can lead to inconsistent estimates if it is correlated with the explanatory variables. Moreover, this factor is most likely to be non-stationary which can cause a spurious regression problem. Therefore, we explicitly model TFP through a common-factor specification. Empirically we exploit the cross-section correlation to identify the unobserved common factor. To this end, we use the Common Correlated Effects Pooled (CCEP) estimator of Pesaran (2006) and Kapetanios et al. (2006). This estimator eliminates the differential effects of unobserved common factors by including cross-sectional averages of the dependent and the explanatory variables. It is a consistent estimator for N (the number of cross sections) going to infinity. Furthermore, extensive Monte Carlo experiments in Pesaran (2006) show that the small sample properties of the CCEP estimator are satisfactory. Kapetanios et al. (2006) prove that the CCEP estimator is consistent regardless of whether the unobserved common factors are stationary or nonstationary. Also using Monte Carlo experiments, they show that this property is supported for small samples. Pesaran (2006) suggests to use an unrestricted version of the CCEP estimator. In this unrestricted version, the factor loadings on the unobserved factors are country-specific and time invariant. However, as can be seen from the specification of TFP in (3), factor loadings are time-varying. In order to allow for these time varying factor loadings, we use a restricted version of the CCEP estimator to estimate (6). To derive this restricted version, we make the assumption that we deal with only one common factor (F_t). From our empirical model in (6), we take cross-sectional averages

$$\overline{Z}_t = \overline{\gamma} + \overline{\lambda}_0 F_t + \lambda \overline{GOVIN}_t F_t + \delta \overline{GOVD}_t + \beta' \overline{X}_t + \overline{\varepsilon}_t, \tag{7}$$

which implies an expression for F_t

$$F_t = \frac{\overline{Z}_t - \overline{\gamma} - \delta \overline{GOVD}_t - \beta' \overline{X}_t}{\overline{\lambda}_0 + \lambda \overline{GOVIN}_t}. \tag{8}$$

The problem, however, is that $\overline{\lambda}_0$, λ , $\overline{\gamma}$, δ and β are not observed when computing F_t. Similarly, F_t is not observed when estimating $\overline{\lambda}_0$, λ , $\overline{\gamma}$, δ and β. That is why we opt for an iterative procedure to come up with a proxy for F_t. In this iterative procedure, we estimate our model (6) with an initial estimate (a constant) for F_t and afterwards we recalculate F_t from (8). Then again we reestimate our model (6) using the new proxy for F_t. Afterwards we recalculate F_t again. We continue doing this until we reach convergence.

We also need to be aware of the fact that at least some of our variables are nonstationary (e.g. real GDP per capita). Therefore, we check for cointegration between the long-run output level and its determinants in (6). A substantial number of panel cointegration tests are based on testing for a unit root in the residuals of a panel cointegrating regression. However, in our particular setting in (6) we do not know the underlying distribution of the residuals, $\hat{\varepsilon}_{it}$. We overcome this problem by using the PANIC approach of Bai and Ng (2004). To apply this principal component analysis, we bring all variables with homogeneous coefficients to the left hand side in equation (6). This gives us the residuals $\widehat{e}_{it}$, which still include $\lambda_{i0} F_t$.

$$\widehat{e}_{it} = Z_{it} - \widehat{\delta} GOVD_{it} - \widehat{\lambda} GOVIN_{it} F_t - \widehat{\beta}' X_{it}. \tag{9}$$

$$= \widehat{\gamma}_i + \widehat{\lambda}_{i0} F_t + \widehat{\varepsilon}_{it}. \tag{10}$$

As N goes to infinity, $\hat{e}_{it}$ can be treated as raw data with factor structure, so we can use the PANIC approach upon $\hat{e}_{it}$. The basic idea of this approach is to split the variable, in this case $\hat{e}_{it}$, into a set of common factors [1] and idiosyncratic components. Both the factors and the idiosyncratic components can be $I(1)$ or stationary. Here we are only interested in the idiosyncratic component, $\hat{\varepsilon}_{it}$. After the decomposition of $\hat{e}_{it}$, we apply a simple Maddala-Wu panel unit root test on the idiosyncratic component. If we can reject the null hypothesis of a unit root, we can state that we are dealing with a cointegrating relationship.

4 Empirical Analysis

We estimate our empirical model (6) for a panel of 17 OECD countries [2] over the period 1975-2007. Before we discuss our results, we look at the data.

4.1 Data

We have three categories of variables: standard variables like physical capital and labor input, fiscal policy variables which influence TFP directly, and policy variables which influence TFP indirectly through their impact on a country's access to and efficient use of the world stock of technology and knowledge. Appendix 1 contains a more detailed description of the data and their sources.

The standard variables consist of real GDP (Y_{it}), real private non-residential net capital stock (K_{it}), real government net capital stock (G_{it}), and total hours worked ($h_{it}L_{it}$).

Among the fiscal policy variables that influence TFP directly ($GOVD_{it}$), we include both government expenditure variables and tax variables. In some regressions we also include the government budget surplus. All variables are expressed in percent of GDP. As government expenditure variables we distinguish total expenditures, productive expenditures [3], social security expenditures, and government consumption (net of education). As tax variables we consider the total tax burden, personal income taxes, corporate income taxes and 'other' taxes received by the government. The latter contain mainly consumption taxes and property taxes. In each equation that we estimate we will include all but one components of the government budget constraint. This approach allows us to control the implicit financing element behind each fiscal policy change that we investigate. It also allows a correct interpretation of the estimated coefficients on each fiscal variable as the effect of a one percent change in the relevant variable offset by a change in the omitted category (Kneller et al., 1999).

The need to account for the government budget constraint also comes at a cost however, especially when the effects of tax changes are involved. The tax variables that we include are so-called macro

[1] The tests confirm our assumption that there is only one common factor

[2] These countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, United Kingom and United States. The selection of countries has been driven by data availability.

[3] Productive expenditures include government financed R&D, education spending and fixed investment

backward-looking indicators. They are computed as the ratio of taxes received by the government to a measure of the tax base. Due to difficulty to find reliable data on the relevant tax base, GDP is often used as a proxy. The issue here is that these indicators may not be the best proxies of actual tax rates that firms and individuals may expect when they take decisions. Thinking about corporate taxes, backward-looking indicators reflect past investment decisions, past tax systems and past profits. Moreover, the amount of corporate tax receipts in the numerator is the product of the tax rate on the one hand and taxable profit on the other. This is a serious drawback, as Devereux (2007) and Backus et al. (2008) point out. Corporate tax receipts in percent of GDP may rise even when tax rates are reduced. Devereux (2007) concludes that there is no straightforward relationship between the two [4]. It should then come as no surprise that correlation between corporate income tax receipts in percent of GDP and tax rates themselves is very low. In Appendix B we report coefficients of correlation with the statutory corporate tax rate (STR) and two so-called micro forward-looking tax variables provided by Devereux and Griffith (2003). These authors rely on the theoretical features of the tax system to compute effective marginal and average tax rates that firms can actually expect for several types of hypothetical investment (see their EMTR and EATR). Correlation over all countries and years in our dataset between the three tax rates (STR, EMTR, EATR) is above 0.6. Correlation with corporate tax receipts in percent of GDP always remains below 0.09. It goes without saying that these findings are a reason for caution when we interpret our results on the direct effects of corporate tax changes on TFP in the next section.
Finally we consider policy variables that influence TFP indirectly through their impact on λ_{it}. Our attention in this paper goes to the effects of changes in governments' corporate tax and education policies. As we have mentioned in section 2, these are also most prominent in the literature when it comes to a country's attractiveness to foreign investors or its ability to adopt foreign technologies. For corporate tax policy, we again face the problem of choosing the right corporate tax rate indicator. Since here we do not have to control for the government budget constraint, we may optimally use the micro-forward looking effective tax rates from Devereux and Griffith (2003). However, for these indicators data availability is limited, they are not available for the 1970s. We therefore use the statutory corporate tax rate (STR). As we have shown before, the latter is highly positively correlated with the EMTR and EATR, meaning that these three indicators pick up the same things. We estimate our equations alternatively with a country's absolute STR and with a country's relative STR in the regression. The relative STR of a particular country is the STR of that country in percent of the average of the STR's of all other countries. In the next section we focus on our results including relative STR as an explanatory variable behind λ_{it}. When it comes to attracting foreign investors by means of tax signals, relative tax rates may be the most

[4] He gives a clarifying example. When a government chooses to lower corporate taxes by means of a lower statutory tax rate or a smaller tax base, this stimulates investment and raises profits. A lower statutory rate may also encourage business to take incorporated form, which implies liability to corporation taxes rather than personal income taxes. As a consequence, corporate income tax revenues could rise, and a lower effective corporate tax rate may even result in a higher macro-backward looking rate.

telling [5]. To study the effects of education policy and human capital formation, we include as a proxy the post-secondary school enrollment rate with a lag of 5 years. When a government raises its educational expenditures this will promote the accumulation of human capital and hence the educational attainment of the population. By lagging the post-secondary school enrollment rate for 5 years, we try to capture the educational attainment of the (young) working age population. The idea is that a rise in educational expenditures and post-secondary school enrollment rates today, will lead to a more skilled workforce in 5 years. Allowing longer lags is not possible for reasons of data availability.
In our empirical analysis, all the policy variables ar expressed in logarithms.

4.2 Results

We begin by testing all series for the presence of a unit root. Since we are dealing with cross-sectional dependence in our variables, we use the PANIC approach of Bai and Ng (2004). From the test results we can only reject the null hypothesis of a unit root for the government budget surplus in percentage of GDP. For all other variables, we cannot reject non-stationarity at the 5 % significance level. In order to avoid a spurious regression problem, we test all our regression specifications for the existence of a cointegrating relationship. For all different specifications we can reject the null of no cointegration at the 5 % significance level.
When turning to the results, we first look at the coefficients on the standard variables. Regression results can be found in table 1. Depending on the different specifications in columns 1 to 4, the private capital income share varies between 0.3495 and 0.3844, the public capital income share between 0.1598 and 0.1985. Both these results are in line with existing literature. Next, we consider the fiscal policy variables that directly influence TFP. We observe that a rise in total government expenditures has a negative effect on TFP, both when it is financed by taxes (column 1) and when it is financed by borrowing (column 3)[6]. When considering the direct effects of a change in the structure of government expenditures, we find in column 1 that a shift in government expenditures from government consumption or rest expenditures (implicit financing elements) towards more productive expenditures, is positive for TFP and hence for long-run per capita output. Concerning social security expenditures, there is no consensus in the literature. Our results are more robust. We find in column 1 that a shift in goverment expenditures towards more social security expenditures influences TFP negatively. This result is also confirmed in column 2 where the implicit financing element is building up more debt. We can conclude that higher productive expenditures are good and higher social expenditures are bad for the long-run output level of an

[5] Alternative results including absolute STR yield smaller, but still significant tax effects. Since such a specification does not control for STR levels in other countries, it is not surprising to find smaller effects. These results are available upon request.

[6] Column 1 investigates the effect of a change in total government expenditure while controlling for the government budget balance. The latter variable is also included in the regression, and therefore kept constant when one interprets the partial effect of a change in expenditures. The total taxburden is not included in the regression in column 1. This variable is therefore not kept constant. It is the implicit financing element in column 1. In column 3 we keep the total taxburden constant, but not the budget balance. So here our implicit financing element is the government budget surplus.

Table 1: Regression results

Dependent variable: $Z_{it} = \left[\ln y_{it} - \ln\left[\frac{h_{it}L_{it}}{N_{it}}\right]\right]$

Sample period: 1975-2007, 17 OECD countries

	(1)	(2)	(3)	(4)
Coefficient estimates				
Standard Variables				
$\ln\left[\frac{K_{it}}{h_{it}L_{it}}\right]$	0.3718***	0.3844***	0.3820***	0.3495***
	(0.0226)	(0.0229)	(0.0231)	(0.0223)
$\ln\left[\frac{G_{it}}{h_{it}L_{it}}\right]$	0.1985***	0.1824***	0.1598***	0.1720***
	(0.0200)	(0.0199)	(0.0205)	(0.0201)
Variables that influence TFP directly: $GOVD_{it}$				
ln Total Government Expenditures	−0.1398***		−0.2001***	
	(0.0396)		(0.0225)	
ln Productive Government Expenditures	0.0872***	0.0622***		0.1122***
	(0.0155)	(0.0145)		(0.0162)
ln Social Security Expenditures	−0.1600***	−0.1710***		
	(0.0167)	(0.0155)		
ln Government Consumption		−0.0812***		
		(0.0213)		
ln Rest Expenditures		−0.0259***		
		(0.0052)		
ln Government Budget Surplus	0.0861			0.4293***
	(0.0554)			(0.0426)
ln Total Taxburden		−0.0155	0.0093	
		(0.0272)	(0.0433)	
ln Personal Taxes			−0.0157	−0.1258***
			(0.0286)	(0.0168)
ln Corporate Taxes		0.0207***	0.0225***	0.0122**
		(0.0050)	(0.0057)	(0.0050)
ln Rest Taxes				−0.1063***
				(0.0191)
Variables that influence TFP indirectly: $GOVIN_{it}$				
ln Relative STR	−0.7681***	−0.8033***	−0.9984***	−0.8052***
	(0.0775)	(0.07842)	(0.0886)	(0.0783)
ln Post-Sec. enrollment rate	0.1330***	0.2278***	0.1686***	0.1907***
	(0.0380)	(0.03729)	(0.0438)	(0.0382)
Cointegration test				
p-value(a)	0.0183	0.0129	0.0145	0.0232

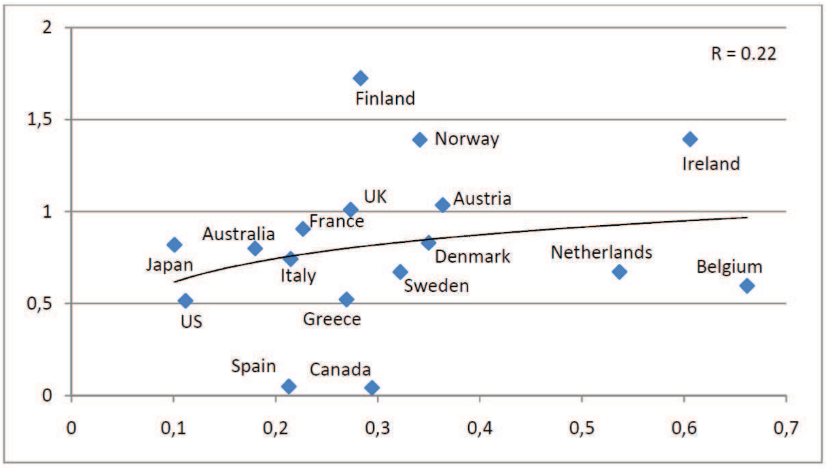
Notes: Standard errors are in parentheses. *, ** and *** indicate significance at the 10%, 5% and 1% level respectively. For a detailed description of data and data sources, we refer to Appendix A. All $GOVD$ variables are variables in percent of GDP (of which we have taken logs). All $GOVIN$ variables are percentages (of which we have taken logs). Because the unobserved common factor F_t is only identified upon a rotating factor, we need to normalize λ in order to be able to interpret the indirect effects of fiscal policy on TFP. We make the assumption that the average access over all time and countries to worldwide available technology is 1. (a): the null hypothesis is the existence of a unit root in the idiosyncratic component of $\hat{e}_{it}$

economy (through TFP). From column 2 we also see that a rise in government consumption, paid by borrowing, has a negative effect on TFP.We proceed by analyzing the direct effect of taxes on TFP in columns 3 and 4 of table 1. From column 3 we can see that a shift in taxes from e.g.

consumption taxes and/or property taxes towards more personal tax revenues has a negative effect on TFP. However, this effect is not significant at the 10 % level. A shift in tax revenues in favour of corporate taxes has a significant positive impact on TFP and hence on the long-run output level. This finding is counterintuitive and not supported by theory. A possible explanation lies in the construction of our tax rates, which we have already discussed in our data section. The incentives of firms may not be captured adequately by the ratio of corporate income tax receipts to GDP. Column 4 shows the effects on TFP of a rise in a tax category, used to finance more government consumption and social security expenditures. For personal taxes and rest taxes (e.g. property taxes and consumption taxes), we find a significant negative effect. Again corporate taxes have the wrong sign. For the reason mentioned above, we do not pay further attention to this positive coefficient. Finally, from columns 1 and 4 we can also derive the effect of government deficit reduction on TFP. In column 1, this deficit reduction is financed by increasing the taxburden whereas in column 4 the implicit financing element is a cut in government consumption and social security expenditures. We see that a reduction of the goverment deficit financed by a cut in unproductive expenditures is very positive for TFP and the long-run output level. When financed by higher taxes however the effect of deficit reduction becomes insignificant. These results confirm earlier findings in the fiscal consolidation literature (e.g. Alesina and Perotti, 1995; Heylen and Everaert, 2000).
We end this section by looking at the policy variables that influence TFP indirectly through their impact on λ_{it} and hence on the access to and efficient use of the world stock of technology and knowledge. In all different specifications, the relative STR has a significant negative coefficient. This means that decreasing the STR in a country, relative to all other countries, increases λ_{it}. This will increase TFP and the long-run output level. Corporate tax policy is thus an effective tool to increase the access to and efficient use of world available technology. From columns 1 to 4, we also see that the post-secondary school enrollment rate has a significant positive effect on λ_{it}. We therefore can conclude that post-secondary school enrollment rate and hence the educational attainment of the population positively affects a country's access to the world stock of technology and knowledge.

Our empirical results also provide an estimate for the time-invariant part of countries' access to world technology, λ_{i0} (see equation (4)). In Figure 1 we report these on the vertical axis and relate them to the degree of openness of the economy. We observe the highest estimates for λ_{i0} in countries like Finland, Ireland and Norway, and low estimates for Spain, Canada and Greece. Existing literature would point at the role of institutions (e.g. Alfaro et al., 2008; Coe et al., 2009). An explorative regression analysis using the institutional data reported by Coe et al. (2009) yields two significant explanatory variables: openness and the quality of tertiary education. Regressing our λ_{i0} on a constant, log(imports/GDP) and a dummy for high quality of tertiary education, we obtain positive and statistically significant coefficients on both variables and an adjusted R^2

Figure 1: Estimated λ_{i0} (vertical axis) as a function of openness (horizontal axis)



Note: our proxy for openness on the horizontal axis is the ratio of imports to GDP (average for 1975-2004).
Sources: λ_{i0} :our estimates (from column 1 in Table 1); openness: Coe et al. (2009).

equal to 0.25. We obtain no significant results in our set of countries for "ease of doing business", patent protection and dummy variables for different legal systems. Extending the analysis by also including data on the perception of corruption and the quality of governance (transparancy international, ICRG) yields no significant results either. All these results are available upon request. The significant role of the quality of tertiary education is in line with our findings on the importance of human capital formation, and literature that we have referred to earlier in this paper (e.g. Krueger and Kumar, 2006; Aghion and Howitt, 2006).

5 Conclusion

This paper analyses the influence of fiscal policy on TFP and per capita output in a panel of 17 OECD countries for the period 1975-2007. We focus on the effects of government size, government deficits and the composition of taxes and expenditures. New is that we are able to identify both direct and indirect effects of fiscal policy on TFP. The latter stem from the influence of taxes and expenditures on countries' access to and use of the world stock of technology. This worldwide available level of technology and knowledge introduces a common factor (and therefore cross-sectional dependence) in individual countries' TFP, and is unobserved. Neglecting it can lead to inconsistent estimates if it is correlated with the explanatory variables. Moreover, this factor is most likely non-stationary which can cause a spurious regression problem. Therefore we explicitly model TFP through a common-factor specification and empirically we exploit the cross-section correlation to identify the unobserved common factor. To this end, we use the Common Correlated Effects Pooled (CCEP) estimator of Pesaran (2006) and Kapetanios et al. (2006). Our main findings are as follows. Through the direct channel, an overall increase in government size reduces TFP and per capita output. Expenditure shifts in favour of productive purposes have strong and robust positive effects on TFP. Shifts in favour of social transfers reduce TFP. Deficit reduction policies raise TFP when they are financed by expenditure cuts. Through the indirect channel, a rise in the corporate tax rate negatively affects a country's access to the worldwide level of technology. Education expenditures and human capital formation promote this access. Our analysis also yields indicative evidence on the role of some institutions for countries' access to worldwide technological progress. More open economies and economies with high quality of tertiary education benefit more.

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Appendices

Appendix A Construction of data and data sources

Standard Variables

Real GDP (=Y_{it})

Source: OECD Statistical Compendium, Economic Outlook (series GDPVD).

Private non-residential net capital stock (=K_{it})

Source: Data from Kamps (2006).

Data adjustments: We extend this data for the period 2003-2007.

Real government net capital stock (=G_{it})

Source: Data from Kamps (2006).

Data adjustments: We extend this data for the period 2003-2007.

Working age population (=N_{it})

Description: Population of the age 15-64.

Source: OECD Statistical Compendium, Labour market and Social issues.

Total annual hours worked (=$h_{it}L_{it}$)

Description: Total annual hours worked in the economy.

Source: The Conference Board and Groningen Growth and Development Centre, Total Economy Database, June 2009.

Policy variables that influence TFP directly (=$GOVD_{it}$)

Government total expenditures in percent of GDP

Source: OECD Statistical Compendium, Economic Outlook (series YPGT, GDP).

Productive government expenditures in percent of GDP

Description: Sum of nominal public expenditures on education, government fixed capital formation and government financed R&D, in percent of nominal GDP.

Sources and data adjustments: Berger and Heylen (2010). See their data appendix for further description.

Government social security expenditures in percent of GDP

Description: Nominal social security benefits paid by general government, in percent of nominal GDP.

Source: OECD Statistical Compendium, Economic Outlook (series SSPG and GDP) and Berger and Heylen (2010).

Government consumption in percent of GDP

Description: Government final consumption net of final consumption expenditures in education, in percent of GDP.

Sources and data adjustments: Berger and Heylen (2010). See their data appendix for further description.

Government rest expenditures in percent of GDP

Description: Government total expenditures in percent of GDP minus productive government expenditures in percent of GDP, government social security expenditures in percent of GDP and government consumption in percent of GDP.

Government Budget Surplus in percent of GDP

Description: Total taxburden minus total government expenditures in percent of GDP.

Data adjustments: Because this variable can be negative, we take the logarithm of 1 plus the government budget surplus.

Total taxburden

Description: Total nominal tax revenues of general government, in percent of nominal GDP.

Source: OECD Statistical Compendium, Financial and Fiscal Affairs.

Personal taxes

Description: Nominal tax revenues of general government of categories 1100 (taxes on income, profits and capital gains of individuals), 2000 (social security contributions) and 3000 (payroll taxes) of the OECD classification of taxes in percent of nominal GDP.

Source: OECD Statistical Compendium, Financial and Fiscal Affairs.

Corporate taxes

Description: Nominal tax revenues of category 1200 (corporate taxes on income, profits and capital gains) of the OECD classification of taxes in percent of nominal GDP.

Source: OECD Statistical Compendium, Financial and Fiscal Affairs.

Rest taxes

Description: Total taxburden minus the sum of personal taxes and corporate taxes. This variable mainly includes nominal tax revenues of consumption and property taxes in percent of nominal GDP.

Policy variables that influence TFP indirectly (=$GOVIN_{it}$)

Statutory corporate income tax rate (=STR)

Source: OECD Tax Database (Table II.1, Corporate income tax rate). We use the combined corporate income tax rate, including both central and sub-central government taxes.
Data shortages and adjustments: The OECD does not present data for 1975-1980. For these years we added the data as collected by Berger and Heylen (2010). See their data appendix for further description.

Post-secondary school enrollment rate

Definiton: Post-secondary school enrollment rate as a percentage of the population aged 15-64. In our empirical setting we include this variable with a lag of 5 years.
Source: Data have been taken from the online UNESCO database.
Data adjustments: UNESCO data are available only for the years 1975, 1980, 1985, 1990, 1995, 2000 and 2005. We have calculated data for the intermediate years by interpolation.

Appendix B Coefficients of correlation between different corporate tax rate indicators

Table 2: Correlation matrix (a)

	$\frac{Corp.taxreceipts}{GDP}$	STR	EMTR	EATR
$\frac{Corp.taxreceipts}{GDP}$	1			
STR	-0.17	1		
EMTR	0.08	0.64	1	
EATR	0.07	0.65	0.93	1

(a): Correlation over 17 countries and 33 years (1975-2007).

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