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Composition of taxes and growth: evidence from OECD panel data

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Abstract
This paper analyzes the impact of the composition of taxes on economic growth using a panel of OECD countries. In contrast to Kneller et al. (*Fiscal policy and growth: evidence from OECD countries*, 1999), over 1980–2005 distortionary taxation did not reduce growth, while an increase in non-distortionary taxation had a negative association with growth. When the data are extended to the great recession and its recovery period (1980–2015), distortionary taxation significantly reduces growth as originally conjectured, but the negative effect of non-distortionary taxation survives. This paper argues that distortions from expenditure taxes in recent years can be accounted for by a combination of an exploding increased debt/GDP and globalization.

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Keywords Distortionary taxation; non-distortionary taxation; growth

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1 Introduction

Does the composition of taxes affect the long-run growth rate? Whilst the neoclassical growth models (see, for example, Solow, 1956; Swan, 1956) indicate no effect of tax and expenditure measures on the steady-state growth rate, in endogenous growth models Jones et al. (1993) and Stokey and Rebelo (1995), building upon Barro (1990), King and Rebelo (1990) and Lucas (1990), extend the analysis and demonstrate the conditions under which fiscal variables can affect growth. More recent theoretical literature (Park and Philippopoulos, 2003; Peretto, 2003; and Peretto, 2007) is also supportive.

Empirical evidence, designed to examine the predictions of endogenous growth models, however, emphasizes the importance of a complete structure of both expenditure and taxation. In contrast to focusing only on the expenditure side in Devarajan et al. (1996), Mendoza et al. (1997) consider exclusively the taxation side and argue that the tax composition has no significant effect on growth even if it produces significant private investment effects. This is borne by a crucial empirical work by Kneller et al. (1999), including a full specification of the government budget constraint. They test the growth effects of fiscal policy for a panel of 22 OECD countries over 1970-95 using the criteria put forward by Barro (1990) to classify relevant fiscal data, and find strong support for the Barro (1990) model. More importantly, they show that distortionary taxation (taxation on income and profit, and so on) reduces growth, whilst non-distortionary taxation (taxation on goods and services) does not; and productive government expenditure (transport and communication expenditure, and so on) enhances growth, whilst non-productive expenditure (social security and welfare expenditure, and so on) does not. More recent empirical studies (see, for example, Lee and Gordon, 2005; Angelopoulos et al., 2007; and Gemmell et al., 2011) all find that public expenditure composition and/or tax structure are correlated with growth.

Following Kneller et al. (1999) the relationship between the composition of taxes and growth is investigated empirically using an updated dataset - a panel of OECD countries over the period 1980-2015, averaged over five year periods.[1] The dependent variable is the growth rate of real GDP per capita, taken from the Penn World Tables. The fiscal data used in this paper are collected from IMF, Government Financial Statistics Yearbook. Following Kneller et al. (1999) this paper treats income and profit taxes, social security contributions, payroll and property taxes as 'distortionary', and consumption (expenditure-based) taxes as 'non-distortionary'. This paper starts with the OECD sample used by Kneller et al. (1999) over the period 1980-2005. The result shows that distortionary taxation does not reduce growth, while an increase in non-distortionary taxation has a negative association with growth. The relationship still holds even if more OECD countries are included. When the data are extended to the great recession as well as its recovery period (1980-2015), an increase in distortionary taxation is found to be negatively associated with per capita GDP growth consistent with the original prediction. Notably within this updated data, however, the negative effect of non-distortionary taxation survives. This negative relationship is robust across different econometric specifications employed, for instance when the budget constraint is even mis-specified, and also when difference GMM estimations are used to deal with potential endogeneity. In the panel estimation with fixed effects and year dummies, a one standard deviation increase in non-distortionary taxation is statistically associated with a fall of 0.54% in average annual growth over the five-year period, holding all else equal. This, therefore, brings about an interesting question - why expenditure taxes, previously described and examined as 'non-distortionary', have now become so 'distortionary'?

In contrast to the Barro (1990) model, expenditure taxes (whether constant or time-dependent) become distortionary and have a negative effect on growth when leisure is entering the utility

[1] Due to the availability of data, this paper can only collect the fiscal data starting from 1980.

function (in other words, labor supply is elastic) as in the Mendoza et al. (1997) model. In this case, expenditure taxes do indirectly distort the decision to invest to the extent that they affect the labor/education-leisure choices, which in turn affect the capital/labor ratio in production. The results in this paper reflect a decline in the effective opportunity cost of leisure by depressing consumption forgone by working less, or labor supply becomes more elastic in other words, in recent period of time.

The common practice of setting expenditure taxes at a variety of rates for different goods and services may lead to distortions in particular in the era of globalization as more various consumption goods are available. These different expenditure tax rates fall on consumption goods that are substitutes or complements brought about by trade liberalization with respect to investment goods, including educational investments, which will finally affect investment incentives. Note that the removal of trade restrictions will result in not only the frequent mobility of goods, but also losses in tax revenue as Khattry and Rao (2002) have analyzed. This occurs because it is difficult for these countries to find alternative sources to replace the forgone revenue from trade. Indeed government deficits will become worrisome if there are not sufficient budget surpluses accompanied later to avoid a boom in government debt/GDP ratio. Figure 1 depicts the data of total gross central government debt measured as a percentage of GDP during 1960-2010, taken from Reinhart and Rogoff (2011), showing OECD countries experienced a period of stasis or even slight decline followed by an upward trend in the later years, rising to 65.71% averagely in 2010. Therefore, distortions from expenditure taxes may arise, in recent years in particular, from an exploding increased debt levels together with insufficient revenue due to globalization.

The next section describes the model and the data. Section 3 contains the estimation results, and section 4 concludes.

2 Data

The agenda in this section is to estimate growth as a function of a bundle of fiscal variables, initial income, investment ratio, the labor force growth rate, and country and period dummy variables - a model similar to that used in most empirical work on fiscal policy and growth. More specifically, I choose this model since it is almost identical to that used by Kneller et al. (1999) in their definitive study finding an negative effect of distortionary taxation on growth whilst no effect of non-distortionary taxation. The main change from Kneller's work is to extend the fiscal data to 2015 as all OECD countries experienced a period of globalization in the later years. Apart from country dummies included to control for time-invariant omitted-variable bias and period dummies included to control for global shocks, estimations in this paper use panel regression with fixed effects and robust standard errors clustered by country. These changes might affect aggregate growth in any period but are not otherwise captured by the existing Kneller et al. (1999) work.

In order to have a better comparison, this paper starts with the same countries sample used in Kneller et al. (1999) over 1980-2005 and check if the relationship between distortionary taxes and growth is negative and significant, and the relationship between non-distortionary taxes and growth is positive or insignificant as shown in Kneller et al. (1999). After that, as shown below the analysis includes data in new OECD countries and more recent periods (1980-2015) step by step to see how results change.

The main dependent variable in this paper is the growth rate of real GDP per capita. Because of data availability, this paper focuses on growth from 1980-2015. Moreover, as yearly growth rates incorporate short-run disturbances, the dependent variable is averaged over five-year periods. This eliminates yearly serial correlation from business cycles. It is thus possible to estimate six periods of GDP per capita growth for each OECD country, and this paper only

includes countries with observations for at least two consecutive periods. Applying these criteria to the preceding dataset results in a sample of 30 countries and 130 observations.

Following Kneller et al. (1999), within the class of endogenous growth models related to this paper, results are driven by the classification of fiscal variables allocated into four categories - distortionary/non-distortionary taxes and productive/non-productive expenditures. In addition to these, this paper also adds the budget surplus of government, revenues and expenditures in which the classification is unclear, labelled by 'other revenue' and 'other expenditures'. These fiscal data are all coming from IMF, Government Financial Statistics Yearbook, aggregated into six main categories in this paper, as described in table 1.

One important determinant of growth is the initial level of development, so I include per capita GDP in constant chained PPP US$, taken from the Penn World Tables, as a first control in the regression analysis. As found in the usual Barro-type regression, the investment ratio (e.g. gross fixed capital formation as a share of GDP) and the labor force growth rate are also included, taken from the World Development Indicators (WDI) database. Further controls employed in the regression follow Persson and Tabellini (2003). Demographic effects are encapsulated in the percentage of the population between 15 and 64 years of age and the percentage over the age of 65 (denoted $Prop1564$ and $Prop65$), also taken from the WDI database. Following Rodrik (1998), the trade share (the sum of exports and imports as a percentage of GDP, denoted $Trade$) is also employed in the regression analysis. To sum up, the growth model central to this section is

$$Growth_{i,t} = \beta_1 DistortionaryTaxes_{i,t} + \beta_2 NondistortionaryTaxes_{i,t} + \mathbf{x}'_{i,t}\Gamma + \alpha_i + \eta_t + u_{i,t} \quad (1)$$

where i represents each country and t represents each time period, control variables analyzed above are included in the vector $\mathbf{x}_{i,t}$, α_i are country dummies, η_t are period dummies, and

$u_{i,t}$ is the error term.

Table 2 lays out some descriptive statistics of all the variables used in the analysis. It can be seen that the sample countries grew, on average, approximately 1.95% per capita per annum, with investment ratios in excess of 23% and labor force growth less than 0.9% per annum. Among the taxation variables, the distortionary tax category yields about twice as much revenue (around 22.5% of GDP on average), as non-distortionary taxes. Figure 2 depicts a scatter plot of GDP per capita and non-distortionary taxes, exhibiting a correlation of around -0.20. Hence this indicates a negative relationship between the income level and non-distortionary taxes over the period 1980-2015, and it is meaningful to examine if non-distortionary taxes reduce growth in recent years whilst it did not occur earlier.

3 Estimation

Table 3 contains the estimation results from fixed effects panel regressions of GDP per capita growth on taxes, with robust standard errors clustered by country, using the same countries sample as in Kneller et al. (1999) over 1980-2005. Column 1 represents the current consensus, augmenting the benchmark controls used in Kneller et al. (1999) with non-productive expenditure as the implicit financing element. In contrast to Kneller et al. (1999) and most empirical literature on taxes and growth, the estimated coefficient for distortionary taxation is positive and even significant, with a p-value of 8.4% and the estimated relationship is sizable: A one standard deviation increase in distortionary taxation by one percentage of GDP is statistically associated with a 0.34% increase in average annual growth. Notably, non-distortionary taxation, on the other hand, is found to be positively and insignificantly associated with per capita GDP growth, in line with Kneller et al. (1999).

Moreover, Kneller et al. (1999) argue that it is important for interpretation of fiscal parameters to fully specify the government budget constraint. They demonstrate that failure to do this, such as omitting or mis-specifying the budget constraint, will lead to serious errors and incorrect conclusions. This paper asks, however, whether the results, non-distortionary taxation in particular, will change with this? The remain columns (columns 2-5), therefore, contain the results with the mis-specified budget constraint. In column 2 of table 3 the three expenditure variables are omitted from the regression, while in column 3 only distortionary and non-distortionary taxation are included. Further, columns 4 and 5 only include one tax variable respectively. In contrast to Kneller et al. (1999), the effect of non-distortionary taxation on growth becomes negative. It is also noteworthy that initial GDP per capita enters the regressions with a significant negative coefficients, implying conditional convergence of growth rates over the period. Columns 1-5 are based on five-year averages of years with the final digits 1-5 and 6-10. This choice was made simply in order to fully use the dataset and generally follow the convention. Columns 6-10 explore the consequences of changing time periods to years with final digits 2-6 and 7-1, which employs a similar number of observations, and duplicate similar results.

Applying the same set of countries, the results above indicate that both the relationship between distortionary taxes and growth and the relationship between non-distortionary taxes and growth have changed when time periods move forward (from 1970-1995 to 1980-2005). It is natural to investigate whether or not the results reported change with the entry or exit of countries. Table 4, therefore, respectively includes the sample of countries joining OECD before 2005 in columns 1-5, and those joining OECD before 2015 in columns 6-10, using the same specification as in columns 1-5 of table 3. The number of observations rises from 52 to 71 in column 6, and the number of countries rises from 19 to 27 concurrently. The results of tax variables are rarely damaged by the entry of new countries, and the significance levels of

two tax variables even increase slightly. This is acceptable as the sample is larger, but more importantly, the negative relationship between non-distortionary taxation and growth still holds up.

Tables 3 and 4 are based on the sample period of 1980-2005, trying to start with a sub-sample as close as possible to that used in Kneller et al. (1999) under the availability of data. It is of interest to see if the negative relationship between non-distortionary taxation and growth will change with the great recession as well as its recovery period. Tables 5 and 6, therefore, mimic tables 3 and 4 but extend to include the unusual period (1980-2015). Consistent with Kneller et al. (1999), the estimated coefficient for distortionary taxation in column 1 of table 5 now becomes negative, with a p-value of 2.1% and the estimated relationship is sizeable: A one standard deviation increase in distortionary taxation by one percentage of GDP is statistically associated with a 0.29% fall in average annual growth. Notably, non-distortionary taxation, on the other hand, is also found to be negatively associated with per capita GDP growth, and statistically significant at the 10% level.

As shown in table 6, the results of tax variables are again rarely damaged by the entry of new countries. The significance levels of both tax variables also increase slightly as the number of observations and countries increases. More importantly, the negative relationship between distortionary/non-distortionary taxation and growth still holds up. Table 7 shows that the broad picture is also similar when this paper focuses on the post-1990 sample (1990-2015), where concerns about whether the relationship is mainly driven by specific periods.

In table 8 this paper explores the consequences of changing time periods to years with final digits 2-6 and 7-1, which employs countries with OECD membership before 2015 over the whole period 1980-2015. The results are broadly similar, although the significance levels of two tax variables tend to be a bit smaller whilst still significantly negative in general.

The point estimates of the coefficients are around -0.22% for distortionary taxation and -0.72% for non-distortionary taxation on average. Note that productive expenditures have a significant and positive coefficients, and the point estimate suggests that an increase by one percentage point of GDP raises the growth rate by 0.35% points on average. Columns 6-10 again test columns 1-5 using demographic variables and openness as further controls, and duplicate similar results.

Easterly and Rebelo (1993) argue that the significance of fiscal variables in the econometric regressions is sensitive to the inclusion or otherwise of the initial income term. The removal of this term collapses the basic regression to a simple form of growth accounting equation. Because the term of initial GDP per capita is a significant regressor in previous tables presented, it would not be surprising if the results are sensitive to the exclusion of it. Columns 1-5 of table 9 contains the estimation results of the regressions with initial income variable excluded. The coefficients of two tax variables are fairly close to those presented in columns of 6-10 of table 6, which in turn implies that in this dataset the significance of tax variables in the growth regression is not sensitive to this change in specification.

The main dependent variable used in this paper is the growth rate of real GDP per capita, averaged over five-year periods. The rest columns of table 9, thus, use alternative measure of growth to test if the results change with different measures of it. Columns 6-10 instead use the difference in log real GDP per capita, which follows another mainstream measure of growth, with initial income control expressed as the lagged log real GDP per capita. The estimated coefficient signs of two tax variables are unchanged and similar to their in columns of 6-10 of table 6. This is not surprising as these two alternative measures of growth are highly correlated, around 0.99.

The estimation of regression (eq [1]) assumes that all of the right-hand side variables are

exogenously determined. As Easterly and Rebelo (1993) mention, the most likely sources of simultaneity in the regression are the effect of business cycle and Wagner's law, which means that higher levels of GDP per capita tend to be higher government expenditure. Averaging over five-year periods attempts to control for the potential effect of business cycle, but due to its imperfection some endogeneity may still remain. However, Wagner's law is less concern here because it indicates a correlation between GDP growth and the growth rate of government expenditure and taxation while here the level of fiscal variables are discussed. To address the concerns about endogeneity, table 10 applies difference GMM by Arellano and Bond (1991) to a panel covering the sample of OECD countries during 1980-2015 in five-year periods. The basic difference GMM regression, eliminating the fixed effects and using lags of the endogenous variables as instruments, produces similar results presented in columns of 6-10 of table 6, in particular, significant and negative coefficients on distortionary and non-distortionary taxation, underpinning the results.

4 Conclusion

This paper analyzes how distortionary and non-distortionary taxation affect per capita GDP growth. Non-distortionary taxation is quite distinct from distortionary taxation. In accordance to Kneller et al. (1999), I treat income and profit taxes, social security contributions, payroll and property taxes as 'distortionary', and consumption taxes as 'non-distortionary'.

This paper starts with the same countries sample as in Kneller et al. (1999) over 1980-2005 and presents some novel results. Distortionary taxation does not reduce growth during this period, whilst it does if the data are extended to the great recession and its recovery period (1980-2015). Notably, non-distortionary taxation, however, has consistent negative

effects on growth throughout all sample period. This negative relationship is robust across different econometric specifications employed, for instance when the budget constraint is even mis-specified, and also when difference GMM estimations are used to deal with potential endogeneity. This paper argues that distortions from expenditure taxes may be caused by, in recent years, an exploding increased debt/GDP ratio together with globalization.

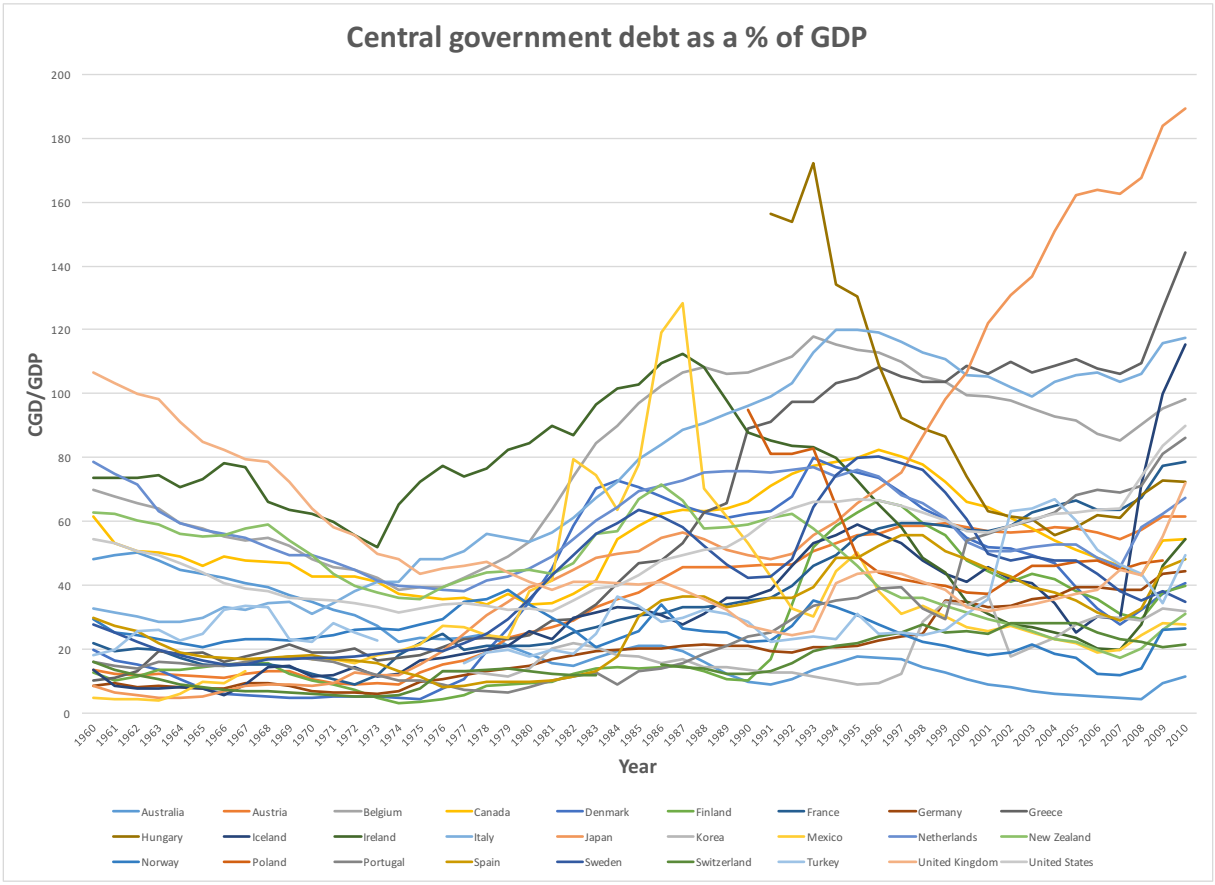

Figure 1: Central government debt as a percentage of GDP

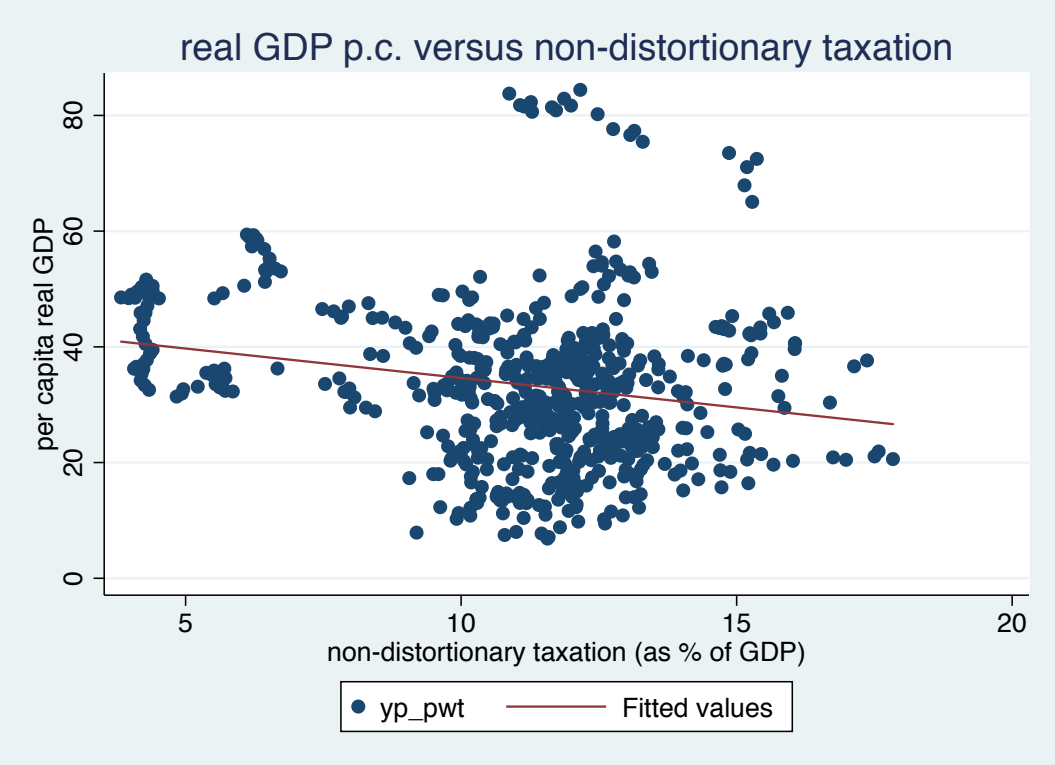

Figure 2: GDP per capita and non-distortionary taxation

Table 1: Theoretical aggregation of functional classifications

Theoretical classification	Functional classification
Distortionary taxation	Taxes on income, profits, and capital gains
	Social security contributions
	Taxes on payroll and workforce
	Taxes on property
Non-distortionary taxation	Taxes on goods and services
Other revenues	Taxes on international trade
	Other tax revenues
	Non-tax revenues
Productive expenditures	Expenditure on general public services
	Expenditure on defence
	Expenditure on education
	Expenditure on health
	Expenditure on housing and community amenities
	Expenditure on transport
	Expenditure on communication
Unproductive expenditures	Expenditure on social protection
	Expenditure on economic affairs
Other expenditures	Other expenditures

Notes: Functional classifications refer to the classifications given in the data source.

Table 2: Descriptive statistics

	obs	mean	std. dev.	min	max
GDP p.c. growth	1,020	1.95	3.55	-34.02	13.35
GDP p.c.	1,025	29.95	13.39	6.85	84.42
Investment	1,034	23.04	4.05	11.55	39.40
Labor force growth	875	0.88	1.56	-4.71	10.85
Net lending	831	0.98	4.01	-29.28	20.67
Distortionary taxation	603	22.45	6.22	4.49	36.66
Non-distortionary taxation	662	11.15	2.78	3.83	17.98
Other revenues	598	7.73	3.59	2.07	26.22
Productive expenditures	580	25.18	4.21	15.27	45.34
Non-productive expenditures	580	16.82	4.74	6.10	28.28
Other expenditures	580	2.33	0.99	-8.91	5.52
Budget surplus	638	-2.27	4.54	-32.12	18.70
Trade	1,034	80.47	48.95	16.01	419.53
*Prop*1564	1,085	66.54	2.60	53.27	73.02
*Prop*65	1,085	13.68	3.72	3.92	26.34

Notes: The table gives descriptive statistics for the variables. Income and resultant growth are taken from the Penn World Tables. The investment ratios and the labor force growth rates are taken from the World Development Indicators (WDI) database. The fiscal data are collected from IMF, Government Financial Statistics Yearbook. The data are consolidated and cover all levels of government. All fiscal variables are expressed as percentages of GDP. *Prop*1564 and *Prop*65 are respectively the proportion of the population aged between 15 and 64, and 65 and above, taken from the WDI database. *Trade* is the sum of exports and imports as a percentage of GDP.

Table 3: Panel regressions of GDP per capita growth on taxes (1980-2005)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	0.312*	0.274**	0.225	0.297**		0.270	0.219	0.119	0.197	
	(0.171)	(0.130)	(0.152)	(0.111)		(0.184)	(0.150)	(0.136)	(0.155)	
Non-distortionary taxation	0.0328	-0.0132	-0.289		-0.652**	-0.290	-0.388	-0.430**		-0.649***
	(0.264)	(0.227)	(0.338)		(0.300)	(0.269)	(0.245)	(0.182)		(0.220)
Initial GDP p.c.	-0.366***	-0.380***	-0.372***	-0.330***	-0.384***	-0.286***	-0.311***	-0.356***	-0.289***	-0.375***
	(0.0895)	(0.0864)	(0.0971)	(0.0634)	(0.0844)	(0.0792)	(0.0734)	(0.0805)	(0.0715)	(0.0669)
Investment	0.0108	0.0105	0.0128	0.0121	0.0658	-0.0159	-0.0202	0.0125	-0.00225	0.0597
	(0.0892)	(0.0895)	(0.0714)	(0.0719)	(0.0821)	(0.0830)	(0.0786)	(0.0570)	(0.0741)	(0.0523)
Labor force growth	-0.306	-0.317	0.0785	0.0598	0.279	0.195	0.183	0.257**	0.234*	0.291***
	(0.222)	(0.219)	(0.226)	(0.233)	(0.251)	(0.152)	(0.150)	(0.105)	(0.118)	(0.0978)
Net lending	0.135	0.122				-0.0339	-0.0705			
	(0.150)	(0.134)				(0.159)	(0.150)			
Other revenues	-0.259	-0.283				-0.278	-0.324*			
	(0.244)	(0.178)				(0.218)	(0.160)			
Other expenditures	0.0777					0.0857				
	(0.0737)					(0.0701)				
Budget surplus	0.0395	0.0987				0.00590	0.129			
	(0.238)	(0.123)				(0.260)	(0.178)			
Productive expenditures	-0.0545					-0.109				
	(0.283)					(0.207)				
Observations	52	52	52	52	61	55	55	56	56	65
Countries	19	19	19	19	22	19	19	19	19	22
Coverage	A	A	A	A	A	A	A	A	A	A
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.846	0.838	0.783	0.773	0.748	0.779	0.771	0.734	0.704	0.753

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. Columns (6)-(10) again test (1)-(5) using alternative five-year period (digits of 2-6 and 7-1 instead of 1-5 and 6-0). *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 4: Panel regressions of GDP per capita growth on taxes (1980-2005)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	0.135	0.0498	0.102	0.142		0.0498	-0.0863	0.0543	0.0954	
	(0.180)	(0.159)	(0.130)	(0.163)		(0.277)	(0.158)	(0.194)	(0.223)	
Non-distortionary taxation	-0.486	-0.586*	-0.575**		-0.664**	-0.693	-0.890*	-1.166**		-1.189**
	(0.348)	(0.320)	(0.247)		(0.242)	(0.569)	(0.476)	(0.480)		(0.471)
Initial GDP p.c.	-0.534***	-0.547***	-0.554***	-0.495***	-0.452***	-0.784***	-0.810***	-0.828***	-0.724***	-0.758***
	(0.103)	(0.105)	(0.103)	(0.136)	(0.0761)	(0.161)	(0.166)	(0.172)	(0.251)	(0.132)
Investment	-0.0976	-0.105	-0.123	-0.125	-0.0222	0.315	0.245	0.217	0.274	0.256*
	(0.119)	(0.114)	(0.105)	(0.126)	(0.0925)	(0.197)	(0.173)	(0.148)	(0.192)	(0.139)
Labor force growth	0.140	0.116	0.321	0.341	0.524*	0.417	0.448	0.590*	0.758*	0.604*
	(0.257)	(0.255)	(0.239)	(0.291)	(0.264)	(0.483)	(0.475)	(0.309)	(0.391)	(0.301)
Net lending	0.163	0.137				0.227	0.187			
	(0.125)	(0.112)				(0.175)	(0.161)			
Other revenues	-0.267	-0.342				0.458	0.281			
	(0.277)	(0.233)				(0.421)	(0.326)			
Other expenditures	0.0473					-0.0643				
	(0.0690)					(0.113)				
Budget surplus	-0.170	-0.0542				-0.382	-0.167			
	(0.263)	(0.142)				(0.296)	(0.186)			
Productive expenditures	-0.139					-0.297				
	(0.286)					(0.333)				
Observations	61	61	63	63	72	71	73	77	77	86
Countries	23	23	23	23	26	27	28	28	28	31
Coverage	B	B	B	B	B	C	C	C	C	C
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.814	0.811	0.773	0.737	0.747	0.845	0.840	0.794	0.753	0.792

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 5: Panel regressions of GDP per capita growth on taxes (1980-2015)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	-0.276**	-0.162*	-0.182**	-0.0844		-0.251**	-0.112	-0.125*	-0.0514	
	(0.110)	(0.0928)	(0.0803)	(0.0790)		(0.0923)	(0.0938)	(0.0713)	(0.0803)	
Non-distortionary taxation	-0.470*	-0.309	-0.511**		-0.539*	-0.638**	-0.445*	-0.534***		-0.596**
	(0.263)	(0.236)	(0.229)		(0.267)	(0.301)	(0.234)	(0.178)		(0.212)
Initial GDP p.c.	-0.261***	-0.239***	-0.251***	-0.152**	-0.272***	-0.271***	-0.253***	-0.260***	-0.152**	-0.303***
	(0.0560)	(0.0538)	(0.0607)	(0.0544)	(0.0550)	(0.0615)	(0.0597)	(0.0569)	(0.0557)	(0.0476)
Investment	0.135	0.126	0.0867	0.109	0.0740	0.0639	0.0724	0.0823	0.0878	0.0780
	(0.0912)	(0.0911)	(0.0962)	(0.130)	(0.0838)	(0.0439)	(0.0476)	(0.0497)	(0.0773)	(0.0461)
Labor force growth	-0.0107	0.146	0.413**	0.386*	0.436***	0.176*	0.241***	0.328***	0.301***	0.357***
	(0.186)	(0.186)	(0.193)	(0.209)	(0.134)	(0.0967)	(0.0783)	(0.0699)	(0.0862)	(0.0500)
Net lending	0.174	0.216*				0.0271	0.101			
	(0.124)	(0.118)				(0.176)	(0.154)			
Other revenues	-0.361***	-0.227				-0.322*	-0.163			
	(0.126)	(0.147)				(0.176)	(0.159)			
Other expenditures	0.125**					0.114				
	(0.0447)					(0.0728)				
Budget surplus	0.150	-0.0944				0.307	-0.00175			
	(0.145)	(0.116)				(0.258)	(0.165)			
Productive expenditures	0.317**					0.388*				
	(0.129)					(0.190)				
Observations	92	93	93	93	106	95	96	97	97	110
Countries	21	21	21	21	23	21	21	21	21	23
Coverage	A	A	A	A	A	A	A	A	A	A
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.799	0.787	0.755	0.720	0.757	0.814	0.802	0.787	0.750	0.800

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. Columns (6)-(10) again test (1)-(5) using alternative five-year period (digits of 2-6 and 7-1 instead of 1-5 and 6-0). *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 6: Panel regressions of GDP per capita growth on taxes (1980-2015)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	-0.363***	-0.273***	-0.238***	-0.211*		-0.400**	-0.324***	-0.299***	-0.245*	
	(0.110)	(0.0790)	(0.0775)	(0.111)		(0.152)	(0.0772)	(0.0929)	(0.120)	
Non-distortionary taxation	-0.568***	-0.452***	-0.534***		-0.550**	-0.795***	-0.689***	-0.792***		-0.790***
	(0.183)	(0.154)	(0.151)		(0.200)	(0.193)	(0.164)	(0.191)		(0.202)
Initial GDP p.c.	-0.358***	-0.331***	-0.317***	-0.218***	-0.314***	-0.536***	-0.516***	-0.496***	-0.383**	-0.466***
	(0.0682)	(0.0603)	(0.0565)	(0.0728)	(0.0443)	(0.0918)	(0.101)	(0.108)	(0.140)	(0.0824)
Investment	0.0585	0.0700	0.0229	0.0161	0.0214	0.179*	0.185**	0.146**	0.170	0.169**
	(0.0742)	(0.0749)	(0.0693)	(0.100)	(0.0700)	(0.0888)	(0.0725)	(0.0656)	(0.102)	(0.0823)
Labor force growth	0.278	0.344*	0.594***	0.578***	0.631***	0.570**	0.621**	0.750***	0.837***	0.698***
	(0.194)	(0.190)	(0.162)	(0.159)	(0.151)	(0.252)	(0.239)	(0.240)	(0.247)	(0.241)
Net lending	0.228**	0.243**				0.254*	0.292**			
	(0.101)	(0.0988)				(0.145)	(0.127)			
Other revenues	-0.261**	-0.200*				0.0190	0.0327			
	(0.107)	(0.111)				(0.240)	(0.183)			
Other expenditures	0.0835					0.0465				
	(0.0577)					(0.0722)				
Budget surplus	-0.0293	-0.140				-0.120	-0.224*			
	(0.153)	(0.112)				(0.213)	(0.128)			
Productive expenditures	0.140					0.1000				
	(0.144)					(0.174)				
Observations	110	112	114	114	127	128	134	138	138	151
Countries	26	26	26	26	28	30	31	31	31	33
Coverage	B	B	B	B	B	C	C	C	C	C
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.769	0.766	0.735	0.685	0.717	0.745	0.738	0.692	0.641	0.662

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 7: Panel regressions of GDP per capita growth on taxes (1990-2015)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	-0.262*	-0.123	-0.150	-0.0376		-0.350**	-0.178**	-0.241**	-0.138	
	(0.150)	(0.142)	(0.121)	(0.120)		(0.159)	(0.0793)	(0.0940)	(0.103)	
Non-distortionary taxation	-0.664***	-0.421**	-0.577**		-0.666**	-0.783***	-0.527***	-0.627***		-0.589***
	(0.225)	(0.194)	(0.214)		(0.319)	(0.222)	(0.148)	(0.169)		(0.208)
Initial GDP p.c.	-0.198***	-0.171**	-0.211***	-0.116	-0.280***	-0.244***	-0.217***	-0.294***	-0.202**	-0.303***
	(0.0633)	(0.0619)	(0.0737)	(0.0823)	(0.0581)	(0.0837)	(0.0728)	(0.0784)	(0.0976)	(0.0480)
Investment	0.118	0.127	0.122	0.138	0.0668	-0.0741	-0.00543	0.00514	0.0335	-0.0100
	(0.0787)	(0.0789)	(0.0891)	(0.131)	(0.0953)	(0.0938)	(0.0784)	(0.0794)	(0.0957)	(0.0811)
Labor force growth	0.193	0.333	0.517**	0.504**	0.576***	0.494	0.538*	0.709***	0.641**	0.668***
	(0.224)	(0.202)	(0.187)	(0.213)	(0.113)	(0.340)	(0.264)	(0.206)	(0.238)	(0.184)
Net lending	0.0303	0.176				-0.101	0.0922			
	(0.181)	(0.199)				(0.157)	(0.139)			
Other revenues	-0.515**	-0.370				-0.607***	-0.472**			
	(0.195)	(0.221)				(0.168)	(0.184)			
Other expenditures	0.104**					0.0879				
	(0.0462)					(0.0623)				
Budget surplus	0.343*	-0.0306				0.507*	0.100			
	(0.182)	(0.197)				(0.249)	(0.142)			
Productive expenditures	0.388**					0.325				
	(0.140)					(0.202)				
Observations	77	78	78	78	88	109	115	116	116	126
Countries	21	21	21	21	23	30	31	31	31	33
Coverage	A	A	A	A	A	C	C	C	C	C
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.848	0.836	0.811	0.773	0.805	0.719	0.707	0.650	0.604	0.669

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 8: Alternative five-year periods regressions (1980-2015)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	-0.389**	-0.184*	-0.205*	-0.156		-0.331**	-0.133	-0.197*	-0.147	
	(0.141)	(0.0947)	(0.108)	(0.111)		(0.133)	(0.107)	(0.105)	(0.112)	
Non-distortionary taxation	-0.928***	-0.673***	-0.659***		-0.668***	-0.810***	-0.579**	-0.726***		-0.774***
	(0.180)	(0.184)	(0.196)		(0.185)	(0.205)	(0.224)	(0.223)		(0.210)
Initial GDP p.c.	-0.563***	-0.532***	-0.460***	-0.354**	-0.437***	-0.530***	-0.495***	-0.480***	-0.374**	-0.452***
	(0.117)	(0.115)	(0.128)	(0.144)	(0.0874)	(0.136)	(0.132)	(0.137)	(0.140)	(0.0906)
Investment	0.169**	0.224***	0.169**	0.186*	0.170**	0.173**	0.235***	0.195**	0.189*	0.204**
	(0.0736)	(0.0682)	(0.0724)	(0.0968)	(0.0770)	(0.0751)	(0.0764)	(0.0819)	(0.0995)	(0.0836)
Labor force growth	0.438**	0.470**	0.496**	0.514**	0.479***	0.315	0.363*	0.461**	0.446*	0.450**
	(0.197)	(0.187)	(0.190)	(0.202)	(0.159)	(0.198)	(0.178)	(0.208)	(0.225)	(0.170)
Net lending	0.122	0.236*				0.0328	0.165			
	(0.159)	(0.129)				(0.135)	(0.115)			
Other revenues	-0.0641	0.0685				-0.126	0.0544			
	(0.205)	(0.174)				(0.229)	(0.182)			
Other expenditures	0.132*					0.113				
	(0.0750)					(0.0898)				
Budget surplus	0.168	-0.163				0.287	-0.105			
	(0.237)	(0.146)				(0.204)	(0.125)			
Productive expenditures	0.326*					0.386**				
	(0.160)					(0.152)				
Trade						0.000521	0.00544	0.0132	0.000301	0.0214*
						(0.00865)	(0.00838)	(0.0105)	(0.0121)	(0.0123)
*Prop*1564						0.424**	0.348**	-0.0423	0.114	-0.0462
						(0.184)	(0.166)	(0.190)	(0.220)	(0.171)
*Prop*65						0.191	0.190	-0.0503	-0.0767	0.0557
						(0.209)	(0.163)	(0.199)	(0.217)	(0.186)
Observations	131	137	143	143	156	131	137	143	143	156
Countries	30	31	31	31	33	30	31	31	31	33
Coverage	C	C	C	C	C	C	C	C	C	C
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.738	0.728	0.656	0.616	0.658	0.753	0.742	0.660	0.620	0.669

Notes: Alternative five-year periods use digits of 2-6 and 7-1 instead of 1-5 and 6-0. Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. Columns (6)-(10) again test (1)-(5) using further control variables. *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 9: Further estimation results (1980-2015)

	Omitted initial income					Dep. var.: difference in log real GDP p.c.				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	-0.225	-0.297***	-0.344***	-0.295**		-0.0140**	-0.0164***	-0.0155***	-0.0134***	
	(0.154)	(0.103)	(0.124)	(0.128)		(0.00653)	(0.00432)	(0.00412)	(0.00438)	
Non-distortionary taxation	-0.201	-0.281	-0.470**		-0.375*	-0.0101*	-0.0129***	-0.0188***		-0.0103
	(0.256)	(0.206)	(0.218)		(0.215)	(0.00556)	(0.00404)	(0.00643)		(0.00644)
Initial GDP p.c.						-0.427***	-0.428***	-0.483***	-0.511***	-0.556***
						(0.0678)	(0.0664)	(0.0648)	(0.0661)	(0.0763)
Investment	0.253	0.217*	0.200*	0.200	0.126	0.0121***	0.0126***	0.0118***	0.0115***	0.0119***
	(0.150)	(0.109)	(0.106)	(0.122)	(0.131)	(0.00397)	(0.00371)	(0.00368)	(0.00412)	(0.00392)
Labor force growth	0.592**	0.618**	0.807**	0.816**	1.067***	0.0160	0.0141	0.0149	0.0147	0.0188
	(0.268)	(0.249)	(0.295)	(0.298)	(0.312)	(0.0116)	(0.0112)	(0.0113)	(0.0114)	(0.0133)
Net lending	0.185	0.175				0.00514	0.00708			
	(0.147)	(0.113)				(0.00461)	(0.00490)			
Other revenues	-0.0768	-0.157				0.00180	0.00278			
	(0.293)	(0.191)				(0.00502)	(0.00504)			
Other expenditures	-0.0519					-0.0106***				
	(0.0828)					(0.00182)				
Budget surplus	-0.288	-0.205				-0.00434	-0.00753			
	(0.309)	(0.121)				(0.00713)	(0.00505)			
Productive expenditures	-0.107					0.00173				
	(0.267)					(0.00732)				
Trade	0.00779	0.00761	0.0118	0.00437	0.0116	0.000267	0.000406	0.000579	0.000284	0.000702
	(0.0158)	(0.0132)	(0.0143)	(0.0118)	(0.0147)	(0.000445)	(0.000426)	(0.000484)	(0.000417)	(0.000589)
*Prop*1564	0.656***	0.626***	0.294	0.379	0.285	0.0460***	0.0419***	0.0385***	0.0426***	0.0445***
	(0.221)	(0.143)	(0.197)	(0.226)	(0.216)	(0.00724)	(0.00500)	(0.00541)	(0.00643)	(0.00648)
*Prop*65	0.914***	0.905***	0.762***	0.638***	0.840***	0.0488***	0.0481***	0.0487***	0.0440***	0.0464***
	(0.210)	(0.186)	(0.230)	(0.212)	(0.229)	(0.00945)	(0.00853)	(0.00913)	(0.00904)	(0.00890)
Observations	128	134	138	138	151	128	134	138	138	151
Countries	30	31	31	31	33	30	31	31	31	33
Coverage	C	C	C	C	C	C	C	C	C	C
Data	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages	5-year averages
R^2 (within)	0.670	0.665	0.600	0.584	0.549	0.897	0.887	0.878	0.867	0.840

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average) in columns (1)-(5) without initial income control; Dependent variable is the difference in log real GDP per capita in columns (6)-(10) with initial income control expressed as the lagged log real GDP per capita. Estimations use panel regression with fixed effects and robust standard errors clustered by country in parentheses. Year dummies are included in all regressions. Columns (6)-(10) again test (1)-(5) using further control variables. *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

Table 10: Difference GMM regressions of GDP per capita growth on taxes (1980-2015)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Distortionary taxation	-0.325**	-0.214***	-0.299***	-0.206		-0.357***	-0.261***	-0.322***	-0.283**	
	(0.149)	(0.0798)	(0.105)	(0.141)		(0.130)	(0.0733)	(0.0883)	(0.120)	
Non-distortionary taxation	-0.746***	-0.592***	-0.634***		-0.566**	-0.724***	-0.639***	-0.724***		-0.862***
	(0.178)	(0.145)	(0.225)		(0.226)	(0.195)	(0.208)	(0.223)		(0.242)
Initial GDP p.c.	-0.541***	-0.501***	-0.439***	-0.358***	-0.475***	-0.514***	-0.485***	-0.435***	-0.329***	-0.457***
	(0.0928)	(0.0964)	(0.0903)	(0.115)	(0.0844)	(0.108)	(0.119)	(0.111)	(0.118)	(0.109)
Investment	0.189**	0.196***	0.120**	0.0799	0.127**	0.208**	0.211***	0.151**	0.121	0.180**
	(0.0877)	(0.0597)	(0.0497)	(0.0749)	(0.0590)	(0.0853)	(0.0709)	(0.0606)	(0.0802)	(0.0718)
Labor force growth	0.605**	0.716***	0.962***	1.175***	0.764**	0.323	0.468*	0.823**	0.959***	0.658**
	(0.274)	(0.259)	(0.351)	(0.377)	(0.343)	(0.265)	(0.253)	(0.358)	(0.367)	(0.297)
Net lending	0.265*	0.331**				0.194	0.218**			
	(0.150)	(0.137)				(0.118)	(0.111)			
Other revenues	-0.0303	-0.0647				-0.0258	0.0263			
	(0.217)	(0.161)				(0.243)	(0.179)			
Other expenditures	-0.0379					0.0162				
	(0.0900)					(0.0646)				
Budget surplus	-0.150	-0.289**				-0.0144	-0.165			
	(0.219)	(0.141)				(0.203)	(0.109)			
Productive expenditures	0.0708					0.151				
	(0.178)					(0.180)				
Trade						0.00513	0.0104	0.00839	-0.00751	0.0222
						(0.0107)	(0.00764)	(0.0105)	(0.00933)	(0.0165)
*Prop*1564						0.383*	0.312*	0.0652	0.250	0.119
						(0.217)	(0.173)	(0.185)	(0.205)	(0.146)
*Prop*65						0.231	0.155	0.0808	0.0376	0.236
						(0.213)	(0.198)	(0.198)	(0.220)	(0.172)
Observations	97	103	107	107	118	97	103	107	107	118
Countries	29	31	31	31	33	29	31	31	31	33
Coverage	C	C	C	C	C	C	C	C	C	C
Hansen test	20.36	23.69	26.14	23.21	25.03	15.81	21.46	22.08	21.47	25.24
AR(2) *p*-value	0.252	0.269	0.246	0.178	0.251	0.210	0.228	0.231	0.155	0.250

Notes: Dependent variable is annual % change in real GDP per capita growth (5-year average). Estimations use the GMM of Arellano and Bond (1991), with robust standard errors. Year dummies are included in all regressions. Endogenous variables used as instruments: initial GDP, investment, labor force growth, all fiscal variables. *, **, and *** respectively denote significance levels at 10%, 5% and 1%. Coverage (A) includes the Kneller et al. (1999) OECD countries sample. Coverage (B) includes countries joining OECD before 2005. Coverage (C) includes countries joining OECD before 2015.

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