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The impact of tax structure on investment: an empirical assessment for OECD countries*

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Abstract

In the present empirical analysis we try to assess the impact of taxation on investment growth. In particular, and by using gross fixed capital formation as a proxy for investment, we intend to evaluate the impact of the taxation structure in investment dynamics, in a short and a long-run perspectives. This empirical exercise was conducted for all OECD countries, during the 1980-2015 period. Through panel data econometric techniques, we find optimal tax-investment threshold values, specially higher for short-term than for long-term evolution. Also, we find optimal income taxation rounding 9%, in percentage of GDP, an average optimal value 12.7% for consumption taxes to promote annual investment growth.

Keywords: Investment Growth; Tax systems; Fiscal Policy; Optimal taxation
JEL: D25; E62; H21; O47

*The opinions expressed herein are those of the author and do not necessarily reflect those of his employers. Any remaining errors are the author's sole responsibility.

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1 Introduction

It is trivial among academics that investment is crucial to promote long-run economic growth. Those decisions enable to sustain consumption in the long-run by applying the economic productive factors in both old and new economic production processes. Therefore, taxation can jeopardize the investment decisions. In particular, the raise of revenues of both income and consumption of individual and the taxation on firms can, on one hand, reduce the level of aggregate consumption, and, on another hand, decrease the investment profitability rates, through the reduction of aggregate demand that those investments are expecting to face.

However, when the investment levels are beyond those, which promote the optimal consumption balanced path, it is imperative to promote the reduction of investment decisions. This happens when the condition of economic dynamic efficiency is not verified, i.e., when the return rate on capital exceeds the economic growth rate. More specifically, it is verified a non-optimal level of investment when the marginal product of capital is lesser than the economic growth rate, as illustrated in several economic exogenous growth theories as, for e.g., in Solow (1956)-Swan (1956) and Ramsey (1928)-Cass (1965)-Koopmans (1963). In contrast to this perspective, when investment levels are below the optimal levels that guarantee a sustainable growth path, there are some viewpoints that claim for government intervention, through the public spending and investment increasing. There are empirical evidences that sustain the possibility of the raise of public investment leading to a crowding-in effect in private investment and, therefore, increases in the aggregate investment levels (Afonso and St. Aubyn (2009), for e.g.). Therefore, it is essential to analyse the taxation effects on investment dynamics, namely, what tax items can jeopardize gross capital formation decisions and those that can promote it, in a short and long run perspectives. Yet, in this study, it is our intention to compute possible non-linear relations between tax items and gross fixed capital formation. In addition, we always consider the overall government expenditures and that the revenues collected by taxes are reintroduced in the economic circuit.

This study is organised in the following sections: section 2 provides a brief review on the existing literature regarding the causalities of taxation on investment; section 2.1 highlights the applied methodology, and the databases used in this analysis; section 3 details the obtained results, and, lastly, section 4 summarizes our conclusions.

2 Literature Review

Some papers address the impact of tax policies on investment behaviour, namely the corporate income tax and its effects on investment decision-making process. We can highlight, for instance, the study conducted by Da Rin et al. (2010) which makes use of panel data techniques to assess the impact of taxation on firms for a set of more than 2.5 million firms in 17 European countries, and for the period between 1997 and 2004. The authors conclude that a corporate tax reduction is related with a decreasing capital-labour ratio,

more specifically, the impact of corporate taxes is stronger on capital than labour firm's proportion. Yet, as the authors highlight, a tax reduction is desired to promote the entrance of firms on the market; however, this policy can also favour the entrance of less financial robust firms. The same conclusion regarding the effect of corporate taxation and the market entry is reached in Braunerhjelm and Eklund (2014). In fact, the authors verified that a 10% reduction in corporate taxation increases the market entry in 3%. Complementing the previous conclusions, Rin et al. (2011) concludes for a non-linear relationship between tax and firms entrance on the market.

For 14 developed countries in the 1982-2007 period, Bond and Xing (2015) find a negative relationship between taxes on firms and its effects on firm's capital–output ratios. The authors develop an econometric specification for both short-run, through the available data, and long-run, derived from a constant elasticity of substitution neoclassical model of investment, and find negative impacts of a 1% increase in firm's taxation on capital-output ratios between -0.3% and -0.7%. These results are also corroborated by Djankov et al. (2010) for a sample of 85 countries in 2004. Moreover, it is also find that manufacturing activities are more exposed to detrimental effects of corporate taxation. Another study that corroborates the previous conclusions is the Mukherjee et al. (2017). Besides the fact of finding a negative impact of taxes on corporate income and R&D activities, the authors also conclude that the consequence of higher taxes is a lesser supply of new goods and services into the market economy. On the other hand, Galindo and Pombo (2011) find that corporate taxes affect more big firms than small and medium size firms in what respects to investment decisions and productivity. In addition, Brandstetter and Jacob (2013) apply a difference-in-differences approach to assess the corporate tax on investment dynamics for the German case, and find heterogeneous responses, i.e., a cut in corporate tax could lead to investment growth for domestic owned firms in a higher extent when compared with foreign-owned corporations. Yet, Baliamoune-Lutz and Garello (2014) found that, contrarily to high-income individuals, tax progressivity stimulates the entrepreneur's entry for the low-to-average income individuals.

In what respects to productivity, for a set of 11 European countries between 1996 and 2005, Gemmell et al. (2016) conclude that while higher statutory corporate tax rates impact negatively in productivity levels of small firms, while productivity of bigger firms is only affected by effective marginal tax rates. Additionally, Langenmayr et al. (2015) shows the existence of optimal corporation tax structure depending on the competition degree. In fact, the authors conclude that when the market competition degree is low, higher taxes favour high productivity firms; when the competition degree tends to the competitive market conditions and firms' profit taxes are low, the low-productivity firms tend to be favoured.

By analysing the effects of consumption taxes on corporate investment decisions, Jacob et al. (2017) conclude that this source of taxation is also detrimental for firm's investment purposes. The results reached by the authors led to the conclusion that the detrimental effect of consumption taxation is stronger for firms with a higher demand elasticity degree, besides of having a higher exposure to the domestic final consumer's degree and to financial restrictions. Another topic is the tax burden and its relationship with risk-taking

decisions for firms' investment. Regarding this, Ljungqvist et al. (2017) conclude that the response to a tax change is not symmetric. In fact, the results suggest that a tax increase is accompanied by a R&D activities' reduction, among others activities. The authors also conclude that only low financial leverage firms react to tax cuts, in what respect risk increasing investment decisions. In addition, a study conducted by Ljungqvist and Smolyansky (2016) about the effect of corporate taxation on employment and income, in the United States between 1970 and 2010, concluded that while corporate taxes' reduction has little impact on economic growth, tax cuts during an economic contraction can raise both levels of employment and income.

2.1 Methodology and Data

In this study, we consider that the investment growth, through the growth of gross fixed capital formation, is a function of taxation composition, denoted by T, of the type $\Delta I = F(T)$.

$$\Delta I_{i,t} = \alpha_{i,t} + \beta_{0,i,t} g_{y_{i,t}} + \sum \beta_{1,i,t} \tau_t + \beta_j x_{i,t} + \nu_i + \eta_t + \varepsilon_{i,t}, j = 1, 2, t = 1, ..., T, i = 1, ..., N \quad (1)$$

where $\Delta I_{i,t}$ is the investment growth rate (annual or 5-years average) - in our case we use gross fixed capital formation growth rate as a proxy variable to measure investment growth -, $g_{y_{i,t-1}}$ is the real *per capita* GDP growth rate, τ_t represents each tax item, as a share of GDP, $x_{i,t}$ is an independent variable belonging to the control variables' set, ν_i and η_t are, respectively, the country and time-specific effects, and $\varepsilon_{i,t}$ is the error term of the white noise-type.

Additionally, we introduce a squared term for each tax component to evaluate the existence of non-linearity effects of tax structure on investment decisions, as demonstrated in equation (2).

$$\Delta I_{i,t} = \alpha_{i,t} + \beta_{0,i,t} y_{i,t-1} + \sum \beta_{1,i,t} \tau_t + \sum \beta_{2,i,t} \tau_t^2 + \beta_j x_{i,t} + \nu_i + \eta_t + \varepsilon_{i,t}, t = 1, ..., T, i = 1, ..., N \quad (2)$$

By deriving equation 2 we obtain equation 3:

$$\frac{\partial \Delta I_{i,t}}{\partial(\tau_{i,t}, \tau_{i,t}^2)} = \frac{\partial(\alpha_{i,t} + \beta_{0,i,t} y_{i,t-1} + \sum \beta_{1,i,t} \tau_t + \sum \beta_{2,i,t} \tau_t^2 + \beta_i x_{i,t} + \nu_i + \eta_t + \varepsilon_{i,t})}{\partial(\tau_{i,t}, \tau_{i,t}^2)} \quad (3)$$

Each tax threshold is computed by equalizing equation (3) to zero, as in equation (4):

$$0 = \beta_1 + 2\beta_{2,i,t} \tau_t \Leftrightarrow \tau_t = \frac{-\beta_{1,i,t}}{2\beta_{2,i,t}} \quad (4)$$

Therefore, if we obtain a significant negative signal for $\beta_{2,i,t}$ we have a concave relation-

ship between a tax item and the investment dynamic, translating into an optimal value for taxation to maximize investment. On the other hand, a convex relationship through a positive coefficient for $\beta_{2,i,t}$ translates into a value that hampers investment growth decisions. Therefore, in the empirical results section when we get convex relations we will highlight that coefficient to differentiate between maximum and minimum optimal levels.

The model herein computed considers the period between 1980 and 2015, for the overall OECD countries: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Chile (CHL), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), Iceland (ISL), Ireland (IRL), Israel (ISR), Italy (ITA), Japan (JPN), South Korea (KOR), Latvia (LVA), Luxembourg (LUX), Mexico (MEX), the Netherlands (NLD), New Zealand (NZL), Norway (NOR), Poland (POL), Portugal (PRT), Slovak Republic (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), United Kingdom (GBR) and United States (USA).

The final database used in our analysis includes data from several sources: the PPP *per capita* GDP (*realgdppc*), the public debt (debt) and the total government spending (totexp), both in ratio of GDP, and output gap, in percent of potential GDP (*outputgap*) are from World Economic Outlook (IMF); taxes on income, profits and capital gains of individuals (*taxinc*), taxes on income, profits and capital gains of corporates (*taxfirms*), social security contributions (*ssc*), taxes on payroll and workforce (*taxpayroll*), taxes on property (*taxprop*), taxes on goods and services (*taxvat*), gross fixed capital formation (*gfcf*) and its growth rate (*gfcfgr*) were retrieved from *OECD.Stats* database, the age dependency ratio, as percentage of active population (*ageratio*), deposit interest rate (*depositrate*), net foreign direct investment-to-GDP ratio (*foreigninvestment*), and the GDP percentage of household final consumption expenditure (*hconsggdp*) are from the World Development Indicators (WDI). Population in millions (pop) and the real total factor productivity (*rtfpna*) are from Feenstra et al. (2015) data. Lastly, while liquid liabilities-to-GDP ratio (llgdp) is based on International Financial Statistics (IFS), IMF. The table 1 presents the summary statistics for each variable used in our regressions[1].

For the coefficients estimation, we resort to panel data techniques, throughout the application of OLS, OLS-Fixed Effects (FE), Generalized Method of Moments (GMM) and Robust Least Squares (RLS) methodologies. With the exception of RLS, those estimations assume the white diagonal covariance matrix hypothesis. Additionally, we estimate both equations (1) and (2) for both annual and 5-years average growth rates. Lastly, we will only discuss the threshold existence when the coefficients of each tax items present statistical significance for both linear and square term items tax regressors, for a minimum of 90% confidence interval.

Table 1: Summary statistics of the variables set for investment regressions, 1980-2015.

	realgdppc	*taxinc*	*taxfirms*	*ssc*	*taxpayroll*	*taxprop*	*taxvat*
Mean	24.448	8.820	2.806	8.345	0.369	1.745	10.588

[1]For reasons of parsimony, the results of realgdppc are expressed in thousands of USD.

Std dev	14.313	4.635	1.500	4.981	0.728	1.003	3.046
Max	101.054	26.780	12.594	19.173	5.661	7.334	18.730
Min	2.184	0.873	0.261	0.000	0.000	0.074	2.979
Obs.	1195	1106	1106	1137	1137	1137	1137
	gfcf	*gfcfgr*	*depositrate*	*ageratio*	*debt*	*foreigninvestment*	*rtfpna*
Mean	23.161	3.314	9.253	51.287	55.728	3.645	0.941
Std dev	4.091	8.917	25.364	6.931	35.901	10.487	0.123
Max	39.404	45.119	682.53	96.457	242.113	252.308	1.539
Min	11.546	-47.761	-0.180	36.323	3.664	-58.323	0.472
Obs.	1174	1164	1055	1260	943	1120	1173
	totexp	*pop*	*hconsggdp*	*outputgap*			
Mean	42.621	33.531	56.382	-0.319			
Std dev	9.657	52.235	7.069	2.85			
Max	68.436	319.449	79.551	14.911			
Min	14.244	0.228	29.918	-11.437			
Obs.	977	1173	1174	851			

3 Results

3.1 Short-run effects of taxation on investment dynamics

The short-run analysis for equation (1), i.e, without the tax items square terms, evidence a negative relation between all type of taxes and investment increasing, as it was expected, with the exception of payroll taxes, which appears to have a positive correlation between the revenue levied by this type of taxes and the investment decisions. In detail, while by an increment of 1% of revenues collected from payroll taxes, in proportion of GDP, the gross capital formation increases by 2%, the negative impact of a one unit increasing in revenues by all mentioned taxes vary approximately between 0.09% and 0.66%.

Moreover, we verify a negative impact in the following variables: deposit interest rates (by about 0.4%), household consumption (0.2%). On contrary, we verify the positive impact of foreign investment, always greater than 0.1%. Looking in detail at the government debt growth impact, it seems that this variable crowds out aggregate investment. On the other hand, and while public expenditures growth and age dependency ratio do not evidence to influence investment decisions, output gap reveals to be favourable to gross fixed capital formation, between 0.27% and 0.74%. This positive effect can be explained by the fact that when the economy is overheating, inflation pressures could decrease the amortization time of the investment, and, consequently, increase its profitability.

In what respects to tax items thresholds for investment decision-making, through the growth rate of gross fixed capital formation, it is possible to verify the non-existence of this thresholds for taxes on payroll and taxes on property. Regarding the other tax items, we reach to a value of 10.65% for taxes on individual income on GDP, which translates the maximum value that promotes investment, while we assist to minimizing values for social security contributions of 12.09%, and 7.37% and 14.18%, on average, for tax on firms and on consumption, respectively. The values reached for the last three tax items evidence their minimum revenue, in GDP proportion, to promote investment growth. The

above-mentioned results are presented in table 2.

Table 2: Linear and non-linear short-run impact results of taxation structure on investment decisions.

	OLS		OLS-FE		GMM		RLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS		OLS-FE		GMM		RLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta realgdppc$	0.004***	0.003***	0.003***	0.003***	0.004***	0.005***	0.004***	0.004***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
$taxinc_{-1}$	-0.144**	-0.069	0.131	1.491**	-0.127	0.037	-0.128**	-0.182
	(0.070)	(0.215)	(0.199)	(0.577)	(0.112)	(0.367)	(0.061)	(0.175)
$taxinc^2_{-1}$		-0.007		-0.070**		-0.015		-0.001
		(0.009)		(0.031)		(0.017)		(0.008)
$taxfirms_{-1}$	-0.442**	-1.580***	0.277	-0.595	-0.561***	-3.859***	-0.289**	-1.032**
	(0.176)	(0.568)	(0.272)	(0.779)	(0.263)	(1.488)	(0.140)	(0.427)
$taxfirms^2_{-1}$		0.107**		0.070		0.279**		0.066*
		(0.044)		(0.060)		(0.115)		(0.039)
ssc_{-1}	-0.121**	-0.436**	-0.047	-2.007**	-0.151	-0.703	-0.086*	-0.276
	(0.058)	(0.209)	(0.230)	(1.013)	(0.095)	(0.437)	(0.050)	(0.180)
ssc^2_{-1}		0.017		0.083**		0.028		0.010
		(0.011)		(0.039)		(0.021)		(0.010)
$taxpayroll_{-1}$	-0.324	0.420	1.990**	3.002	-0.065	-2.013	-0.284	0.107
	(0.262)	(0.929)	(0.968)	(1.904)	(0.381)	(1.546)	(0.277)	(0.934)
$taxpayroll^2_{-1}$		-0.365		-0.304		0.729		-0.144
		(0.356)		(0.540)		(0.682)		(0.383)
$taxprop_{-1}$	-0.571*	-0.588	-0.211	0.775	-0.036	3.822	-0.013	1.139
	(0.295)	(1.025)	(0.508)	(1.521)	(0.649)	(2.793)	(0.255)	(0.770)
$taxprop^2_{-1}$		0.042		-0.118		-0.658		-0.208
		(0.166)		(0.214)		(0.443)		(0.141)
$taxvat_{-1}$	-0.612***	-2.640***	0.413	0.291	-0.103	-2.691*	-0.663***	-1.982***
	(0.163)	(0.635)	(0.363)	(1.127)	(0.3)	(1.519)	(0.133)	(0.538)
$taxvat^2_{-1}$		0.099***		0.016		0.111		0.066**
		(0.033)		(0.057)		(0.072)		(0.026)
$gfcf_{-1}$	-0.521***	-0.615***	-1.283***	-1.337***	-0.077	-0.340	-0.505***	-0.599***
	(0.104)	(0.123)	(0.148)	(0.159)	(0.111)	(0.208)	(0.072)	(0.079)
$gfcfgr_{-1}$	0.242***	0.242***	0.225***	0.221***	0.429**	0.267	0.259***	0.257***
	(0.057)	(0.058)	(0.061)	(0.061)	(0.183)	(0.169)	(0.032)	(0.032)
$\Delta depositrate$	-0.426*	-0.435*	-0.436*	-0.414*	1.063	-1.323	-0.583***	-0.606***
	(0.241)	(0.238)	(0.256)	(0.251)	(1.233)	(1.526)	(0.160)	(0.159)
$ageratio_{-1}$	-0.016	-0.053	-0.065	-0.029	-0.044	-0.029	-0.027	-0.058
	(0.067)	(0.071)	(0.137)	(0.144)	(0.116)	(0.104)	(0.053)	(0.055)
$\Delta debt$	-0.275***	-0.303***	-0.189**	-0.200**	-0.487*	-0.543**	-0.264***	-0.295***
	(0.078)	(0.082)	(0.082)	(0.084)	(0.258)	(0.218)	(0.047)	(0.047)
$rtfpna$	-12.705***	-12.809***	-6.562	-2.947	2.829	-0.873	-10.328***	-10.345***
	(3.769)	(3.884)	(5.536)	(6.308)	(4.246)	(5.567)	(2.677)	(2.770)
$\Delta totexp_{-1}$	-0.148	-0.160	-0.088	-0.081	0.315	-0.139	0.053	0.032
	(0.159)	(0.163)	(0.154)	(0.157)	(0.654)	(0.602)	(0.104)	(0.104)
$\log(pop)$	-0.497	-0.580	61.785***	63.702***	0.228	-0.501	-0.926***	-0.997***
	(0.397)	(0.396)	(10.841)	(11.771)	(0.878)	(0.974)	(0.237)	(0.243)
$foreigninvestment_{-1}$	-0.075***	-0.066***	-0.070***	-0.066***	0.028	0.009	-0.075***	-0.073***
	(0.017)	(0.016)	(0.017)	(0.017)	(0.087)	(0.091)	(0.015)	(0.015)
$hconsumption_{-1}$	0.039	0.013	-0.214**	-0.242**	0.07	0.000	0.036	0.024
	(0.027)	(0.028)	(0.093)	(0.094)	(0.048)	(0.049)	(0.027)	(0.028)
$outputgap$	0.369**	0.466***	0.690***	0.736***	-0.849**	0.121	0.271***	0.352***
	(0.157)	(0.157)	(0.159)	(0.170)	(0.395)	(0.565)	(0.091)	(0.093)
Tax thresholds								
$taxinc$	-	-	-	10.65%	-	-	-	-

taxfirms	-	**7.38%**	-	-	-	**6.92%**	-	**7.82%**
ssc	-	-	-	**12.09%**	-	-	-	-
taxpayroll	-	-	-	-	-	-	-	-
taxprop	-	-	-	-	-	-	-	-
taxvat	-	**13.33%**	-	-	-	-	-	**15.02%**
R-squared	0.540	0.554	0.680	0.687	0.343	0.477	0.401	0.414
DW-Stat	1.856	1.875	2.000	2.018	2.110	1.949	n.a.	n.a.
Obs.	529	529	529	529	473	473	529	529

Notes: *, ** and *** represent statistical significance at levels of 10%, 5% and 1% respectively. The robust standard errors are in brackets. The White diagonal covariance matrix is used in order to assume residual heterokedasticity, with the exception for RLS technique. The DW-statistic is the Durbin-Watson statistic. The non-bold and bold values express, respectively, maximum and minimum optimal tax items levels.

3.2 Long-run effects of taxation on investment dynamics

In a long-run perspective, and in a linear relationship (see regressions (9), (11), (13) and (15)), the results obtained highlight similar patterns for the verified short-run effects on tax items and investment growth, with the exception for the tax on property that appears to be not relevant to determine investment decisions. In addition, we can observe that the values presented in tables 2 and 3 highlight similar magnitudes for the tax items coefficients in investment growth.

Regarding the other control variables, and similar to the short-run perspective, population size evidences a contradictory signal. Moreover, household consumption and output gap variables highlight a non-clear effect on investment dynamics, since these last two variables also present different signals, depending on the econometric technique used.

Yet, it seems that the deposit interest rates had a negative effect on investment in a long-term perspective. Specifically, by a 1 p.p. increase in deposit interest rates, the investment tend to decrease between 0.4 p.p. and 0.6 p.p., approximately. Additionally, the government spending variation also seems to gain importance in the long-term, presenting a slightly negative impact on capital formation.

In what respects to the analysis of the non-linear relationships of tax items on investment decision, and by computing the consequent existing tax items-to-investment thresholds, we find maximum values of 6.27% and 9.19% for taxation on firms' profits and for consumption taxes, respectively. On the opposite side, we find a minimum threshold value for social security contributions of 11.35%. In the long run, we can also observe that the optimal for taxes on payroll disappears. The above-discussed results may be observed in detail in table 3.

Table 3: Linear and non-linear long-run impact results of taxation structure on investment decisions.

	OLS		OLS-FE		GMM		RLS	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
$\Delta realgdppc$	0.000**	0.000**	0.003***	0.001**	0.004***	0.001**	0.004***	0.000*
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
$taxinc_{-1}$	-0.042	-0.085	0.131	0.740	-0.127	-0.263	-0.128**	0.021

	(0.051)	(0.091)	(0.199)	(0.571)	(0.112)	(0.169)	(0.061)	(0.114)
$taxinc^2_{-1}$		0.003		-0.042		0.012*		-0.004
		(0.004)		(0.029)		(0.007)		(0.005)
$taxfirms_{-1}$	-0.098	-0.197	0.277	0.489	-0.561**	-0.601	-0.289**	-0.828***
	(0.107)	(0.458)	(0.272)	(0.747)	(0.263)	(0.734)	(0.140)	(0.278)
$taxfirms^2_{-1}$		0.014		-0.028		0.041		0.066***
		(0.034)		(0.053)		(0.055)		(0.025)
ssc_{-1}	-0.069**	-0.227**	-0.047	-0.417	-0.151	-0.150	-0.086*	-0.255**
	(0.034)	(0.091)	(0.230)	(0.662)	(0.095)	(0.172)	(0.050)	(0.117)
ssc^2_{-1}		0.010*		0.008		0.006		0.009
		(0.005)		(0.023)		(0.010)		(0.006)
$taxpayroll_{-1}$	-0.168	0.170	1.990**	1.156	-0.065	0.221	-0.284	-0.164
	(0.160)	(0.490)	(0.968)	(1.352)	(0.381)	(0.986)	(0.277)	(0.608)
$taxpayroll^2_{-1}$		-0.215		-0.467		-0.334		-0.044
		(0.185)		(0.503)		(0.415)		(0.249)
$taxprop_{-1}$	-0.258	-0.971	-0.211	-0.816	-0.036	-1.381	-0.013	0.447
	(0.181)	(0.868)	(0.508)	(1.838)	(0.649)	(1.260)	(0.255)	(0.501)
$taxprop^2_{-1}$		0.137		0.122		0.190		-0.052
		(0.124)		(0.219)		(0.198)		(0.092)
$taxvat_{-1}$	-0.271**	-0.183	0.413	1.985***	-0.103	0.298	-0.663***	-0.499
	(0.109)	(0.397)	(0.363)	(0.571)	(0.300)	(0.853)	(0.133)	(0.350)
$taxvat^2_{-1}$		-0.007		-0.108***		-0.040		0.022
		(0.021)		(0.029)		(0.035)		(0.017)
$gfcf_{-1}$	-0.114*	-0.100	-1.283***	-0.259***	-0.077	0.096	-0.505***	-0.083
	(0.062)	(0.069)	(0.148)	(0.091)	(0.111)	(0.115)	(0.072)	(0.052)
$gfcfgr_{-1}$	0.274***	0.267***	0.225***	0.214***	0.429**	0.265***	0.259***	0.292***
	(0.034)	(0.036)	(0.061)	(0.036)	(0.183)	(0.100)	(0.032)	(0.021)
$\Delta Depositrate$	-0.648***	-0.644***	-0.436*	-0.468***	1.063	-0.388	-0.583***	-0.573***
	(0.124)	(0.191)	(0.256)	(0.131)	(1.233)	(0.815)	(0.160)	(0.104)
$ageratio_{-1}$	-0.064	-0.053	-0.065	-0.052	-0.044	0.089**	-0.027	-0.071**
	(0.040)	(0.032)	(0.137)	(0.112)	(0.116)	(0.045)	(0.053)	(0.036)
$\Delta debt$	-0.239***	-0.238***	-0.189**	-0.150***	-0.487*	-0.631***	-0.264***	-0.245***
	(0.050)	(0.057)	(0.082)	(0.041)	(0.258)	(0.124)	(0.047)	(0.031)
$rtfpna$	-4.849**	-4.240*	-6.562	0.082	2.829	1.089	-10.328***	-4.070**
	(2.074)	(2.551)	(5.536)	(4.644)	(4.246)	(3.229)	(2.677)	(1.803)
$\Delta totexp_{-1}$	-0.046	-0.050	-0.088	0.002	0.315	0.517	0.053	-0.125*
	(0.091)	(0.077)	(0.154)	(0.079)	(0.654)	(0.327)	(0.104)	(0.068)
$\log(pop)$	-0.436**	-0.421	61.785***	14.650**	0.228	-0.203	-0.926***	-0.415***
	(0.189)	(0.299)	(10.841)	(7.225)	(0.878)	(0.391)	(0.237)	(0.158)
$foreigninvestment_{-1}$	-0.004	-0.002	-0.070***	-0.006	0.028	0.044	-0.075***	-0.003
	(0.007)	(0.006)	(0.017)	(0.009)	(0.087)	(0.047)	(0.015)	(0.010)
$hconsumption_{-1}$	0.056***	0.053***	-0.214**	-0.093	0.070	0.057**	0.036	0.026
	(0.018)	(0.018)	(0.093)	(0.102)	(0.048)	(0.028)	(0.027)	(0.018)
$outputgap$	-0.144*	-0.138	0.690***	-0.085	-0.849**	-0.433	0.271***	-0.214***
	(0.083)	(0.103)	(0.159)	(0.091)	(0.395)	(0.312)	(0.091)	(0.061)
Tax thresholds								
taxinc	-	-	-	-	-	-	-	-
taxfirms	-	-	-	-	-	-	-	6.27%
ssc	-	**11.35%**	-	-	-	-	-	-
taxpayroll	-	-	-	-	-	-	-	-
taxprop	-	-	-	-	-	-	-	-
taxvat	-	-	-	9.19%	-	-	-	-
R-squared	0.476	0.481	0.717	0.730	0.171	0.180	0.360	0.366
DW-Stat	1.124	1.127	1.034	1.095	1.692	1.665	n.a.	n.a.
Obs.	529	529	529	529	473	473	529	529

Notes: *, ** and *** represent statistical significance at levels of 10%, 5% and 1% respectively. The robust standard errors are in brackets. The White diagonal covariance matrix is used in order to assume residual heterokedasticity, with the exception for RLS technique. The DW-statistic is the Durbin-Watson statistic. The non-bold and bold values express, respectively, maximum and minimum optimal tax items levels.

4 Concluding Remarks

In this study, we developed an empirical model to assess possible relations between tax composition, in GDP proportion, and investment growth. To perform this exercise we used gross fixed capital formation as a proxy variable for investment, and our empirical analysis resorted to panel data techniques to analyse tax effects in both short and long-term. In addition, we assessed the existence of non-linear relationships between tax items and investment growth.

The obtained results evidenced the existence of some tax-to-GDP thresholds. Namely, there were some optimal values of tax items, in share of GDP, which maximizes the investment decisions. In particular, and regarding the short-run, we reach a maximizing threshold, which promotes long-run investment growth of 10.65% for taxes on individual income. On the other hand, in the end, we conclude for maximum threshold levels for taxes on firms' profits and taxes on consumption of goods and services of 6.27% and 9.19%, respectively, to promote investment growth. Moreover, we found a minimum threshold of 11.35% of social security contribution.

In what respects the short-run, we found only one maximum threshold of 10.65% for taxes on individual income, while it is found a minimum threshold value of 12.09% for social contributions. In addition, we found minimum threshold values, on average, of 7.37% and 14.18% for profits and consumption of goods and services taxes, respectively.

Lastly, and resorting to the results presented in table 1 which allow the comparison of the short and long-term results for each tax items from the econometric regressions, we were also able to conclude that there are some fiscal space to raise some taxes to promote higher investment growth rates, mainly in a short-run perspective. In particular, with the exception of payroll taxes and taxes on property on firms, we did not find any optimal value - it seems that the raise of the other taxes tends to be a favourable political measure to promote investment growth. Moreover, if we sum all the optimal threshold tax items values with the historical average recorded for taxes, we conclude that taxation over the GDP should be around 46.41% and 37.75% in the short-run and long-run, respectively. The table 4 summarizes our main findings regarding average tax threshold values.

Table 4: Summary of tax items threshold values for investment decisions.

	Short-run	Long-run	**Mean**
taxinc	10.65%	-	8.82%
taxfirms	***7.37%***	6.27%	2.81%
ssc	**12.09%**	**11.35%**	8.35%
taxpayroll	-	-	0.37%
taxprop	-	-	1.75%
taxvat	***14.18%***	9.19%	10.59%

Notes: The non-bold and bold values, presented in the short-run and long-run columns express maximum and minimum optimum levels, respectively. The values expressed in *italics* represent average values.

References

Afonso, A. and St. Aubyn, M. (2009). Macroeconomic Rates of Return of Public and Private Investment: Crowding-in and Crowding-out Effects. *The Manchester School*, 77:21–39.

Baliamoune-Lutz, M. and Garello, P. (2014). Tax structure and entrepreneurship. *Small Business Economics*, 42(1):165–190.

Bond, S. and Xing, J. (2015). Corporate taxation and capital accumulation: Evidence from sectoral panel data for 14 OECD countries. *Journal of Public Economics*, 130(Supplement C):15 – 31.

Brandstetter, L. and Jacob, M. (2013). Do corporate tax cuts increase investments? Arqus-Diskussionsbeiträge zur quantitativen Steuerlehre 153.

Braunerhjelm, P. and Eklund, J. E. (2014). Taxes, tax administrative burdens and new firm formation. *Kyklos*, 67(1):1–11.

Cass, D. (1965). Optimum Growth in an Aggregative Model of Capital Accumulation. *The Review of Economic Studies*, 32(3):233–240.

Da Rin, M., Sembenelli, A., and Di Giacomo, M. (2010). CORPORATE TAXATION AND THE SIZE OF NEW FIRMS: EVIDENCE FROM EUROPE. *Journal of the European Economic Association*, 8(2-3):606–616.

Djankov, S., Ganser, T., McLiesh, C., Ramalho, R., and Shleifer, A. (2010). The Effect of Corporate Taxes on Investment and Entrepreneurship. *American Economic Journal: Macroeconomics*, 2(3):31–64.

Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, 105(10):3150–3182.

Galindo, A. J. and Pombo, C. (2011). Corporate taxation, investment and productivity: A firm level estimation. *Journal of Accounting and Taxation*, 5(7):158–161.

Gemmell, N., Kneller, R., McGowan, D., Sanz, I., and Sanz-Sanz, J. F. (2016). Corporate Taxation and Productivity Catch-Up: Evidence from European Firms. *The Scandinavian Journal of Economics*, pages 0–34.

Jacob, M., Michaely, R., and Müller, M. A. (2017). Consumption taxes and corporate investment. Technical report. Available at SSRN: https://ssrn.com/abstract=2800146https://ssrn.com/abstract=2800146.

Koopmans, T. C. (1963). On the Concept of Optimal Economic Growth. Technical Report 163, Cowles Foundation for Research in Economics, Yale University.

Langenmayr, D., Haufler, A., and Bauer, C. J. (2015). Should tax policy favor high- or low-productivity firms? *European Economic Review*, 73(Supplement C):18 – 34.

Ljungqvist, A. and Smolyansky, M. (2016). To Cut or Not to Cut? On the Impact of Corporate Taxes on Employment and Income. Finance and Economics Discussion Series 2016-6, Board of Governors of the Federal Reserve System (U.S.).

Ljungqvist, A., Zhang, L., and Zuo, L. (2017). Sharing Risk with the Government: How Taxes Affect Corporate Risk Taking. *Journal of Accounting Research*, 55(3):669–707.

Mukherjee, A., Singh, M., and Žaldokas, A. (2017). Do corporate taxes hinder innovation? *Journal of Financial Economics*, 124(1):195 – 221.

Ramsey, F. P. (1928). A Mathematical Theory of Saving. *The Economic Journal*, 38(152):543–559.

Rin, M. D., Giacomo, M. D., and Sembenelli, A. (2011). Entrepreneurship, firm entry, and the taxation of corporate income: Evidence from Europe. *Journal of Public Economics*, 95(9):1048 – 1066.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1):65–94.

Swan, T. W. (1956). Economic Growth and Capital Accumulation. *Economic Record*, 32(2):334–361.