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A Tale of Two Taxes: State-Dependency of Tax Policy

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Abstract

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Keywords

Panel Smooth Transition, Fiscal Policy, Tax Policy, Growth

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Abstract

Previous literature provided mixed evidence regarding the effects of two major tax instruments, namely, labor income taxes and corporate taxes on economic growth. We hypothesize that the mixed evidence may be due to state-dependency of labor taxes. While corporate taxes retard economic growth by discouraging entrepreneurship in a linear fashion, the negative effect of labor taxes on growth may depend on the state of the economy, and may, thus, be non-linear. We provide a simple theoretical model which supports the latter hypothesis, and empirically test our predictions by using both statutory and average tax rates for a sample of 19 OECD countries over the 1981–2005 period. We also contribute to the literature by employing a newly developed Panel Smooth Transition (PSTR) model that controls for non-linearities in the tax structure-economic growth relationship. Our empirical findings suggest that while taxes on corporate income are distortionary for growth in both high- and low-growth regimes, taxes on labor income are harmful only during the high-growth regime.

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1 Introduction

A corpus of literature has advanced compelling but contradicting arguments regarding the role of fiscal policy in economic growth. The neoclassical growth model (Solow, 1956; Swan, 1956) predicts no long-run effect of government policy on the rate of economic growth. However, in endogenous growth paradigm, some of the fiscal policy instruments are harmful for growth (Barro, 1991; Lucas, 1990).

Empirical evidence on the effects of fiscal policy on growth is also quite mixed. Many cross-country studies, such as Easterly and Rebelo (2002) and Mendoza et al. (1997), find that long-run growth rates do not respond to taxation. In contrast, Kneller et al. (1999), using a panel of 22 OECD countries, contend that while distortionary taxation (labor and corporate taxes) reduces economic growth, non-distortionary taxation (indirect and consumption taxes) does not.[1] Kneller et al. (1999) use the average tax rates as a measure of tax policy. On the other hand, Lee and Gordon (2005) demonstrate, using a cross-section dataset for 70 countries over the 1970-1997 period, that top marginal corporate tax rate (or, statutory rate) exerts a significant and negative effect on economic growth. Interestingly, they do not find a significant effect of income taxes on growth. The difference in the results of Kneller et al. (1999) and Lee and Gordon (2005) can be due to either the identification of tax shocks (average vs. statutory rates) or, sample size (22 vs 70 countries), or different model specifications. Finally, we should also note that recently Mertens and Ravn (2013) showed that it is important to discriminate between labor and corporate taxes even in the short-run, as both cuts in both types of taxes increase private sector investment, but only cuts in labor taxes stimulate private consumption.

There is an additional important factor in the tax structure-economic growth relationship that has become increasingly important but been ignored by most of the previous studies: non-linearities. The main idea behind non-linearities in the tax structure-growth relationship is that heterogeneous tax effects of growth may arise due to differential impacts under recessionary versus expansionary periods, or critical thresholds in certain variables such as the government budget deficit, economic growth, or the tax rate. A recent line of literature has documented the prominent role of non-linearities in determining the course of the fiscal policy-economic growth association, see Adam and Bevan (2005), Arin et al. (2013), Sims and Wolff (2018).

The primary objective of this paper is to investigate the ways in which taxation policy, which spans both corporate and labor income taxes, could explain the observed differences in countries' economic growth rates. Our approach is to reconcile the differences established in the previous literature, and propose a unified framework that draws upon both theoretical and empirical modeling. Our starting point is that while the negative effect of corporate taxes on economic growth is more or less established (Lee and Gordon, 2005), empirical evidence is less convincing for labor

[1] Further, productive government expenditure enhances growth, while non- productive expenditure does not.

taxes. Thus, we provide a theoretical model that sheds light on the ways in which individual labor income taxes might have an effect on economic growth. Here we conjecture that the documented non-linearities in the fiscal policy-economic growth nexus may be behind the mixed evidence. Our theoretical model shows that labor taxes produce dissimilar distortions depending on the state of the economy, namely, booms vs recessions. In particular, while taxes on labor income can be harmful during the high-growth regime, their effect can be insignificant during the low-growth regime. Intuitively, during recessions, people expect higher chances of becoming unemployed. This channel, reinforced with the fact that consumers might form habits in their expenditure patterns, leads to a greater labor supply response when individual wage income taxes rise.

To provide a background for the primary contribution of our theoretical model, we note that corporate taxation works mainly through the activities of business owners and corporations. It is well accepted that taxing corporations encourages businesses to relocate overseas, discourages investment, distorts the pattern of investment between corporate and non-corporate sectors, and reduces capital accumulation (and thus ultimately incomes). Business owners, corporations, and those individuals who are aspiring business people would (by and large) behave differently than ordinary people who work for someone in a traditional labor market. This is true during recessions and expansions; this negative effect is well documented in Lee and Gordon (2005). Turning to labor taxes, ordinary people can be more prone to habit formation in consumption and might be sensitive to chances of unemployment in a stagnating economy. It is hard to argue against the fact that labor income taxation creates a plethora of complex distortions both on the demand and the supply side of the economy. As we show, however, it is also possible that despite various distortions, higher income taxes in a recessionary environment more strongly stimulate some aspects of labor supply, thus mitigating or offsetting those distortions. Taken together, while highly distortive corporate income tax would very well be harmful to growth irrespective of the state of the economy, individual labor income taxation can have dissimilar distortionary effects depending on the state of the economy.

Next, we take these predictons to data. In this vein, our empirical analysis contributes to the tax structure-economic growth literature in two respects. First, we empirically investigate the effects of both average and top statutory tax rates, for both labor as well as corporate taxes, using a panel of 19 OECD countries over the period 1981 to 2005. Here, we compare and contrast the effects of different taxes and tax brackets on economic growth. Second, we study the non-linear effects of different taxes (as well as different tax measures) on economic growth. To this end we propose a new methodology, namely, the panel smooth transition method with common correlated effects (a la Pesaran, 2006), which is a variant of the class of panel smooth transition methodologies recently developed in the literature (see, among others, Gonzalez et al., 2017). The panel smooth transition method (hereafter, PSTR) models, unlike simple threshold and Markov-Switching models, do not use abrupt changes in coefficients and allow for modelling different types of nonlinear and asymmetric dynamics depending on the type of the transition function (Teräsvirta and Anderson, 1992; Granger and Teräsvirta, 1993). Our empirical results document that taxes on corporate income are distortionary for growth in both high- and low-growth regimes, while taxes on labor income are harmful only during the high-growth regime. Our results hold important policy conclusions and implications given current austerity debates as well as fiscal policy being the only fine-tuning tool available to many governments.

The remainder of the paper is organized as follows: Section 2 provides a theoretical model that explains why the effect of labor taxes on growth is dependent on the state of the economy. Section 3 discusses the data and empirical methods used in testing the hypothesized predictions. Section 4 presents the results and finally, section 5 concludes.

2 The Theoretical Background for Labor Taxes

Time is discrete, and the current date is called period t. Individuals live for three periods: 0, 1, 2. A representative agent works in the first two periods of life, and retires in the third period. Time endowment is unity, and labor supply decision is endogenous. In the first and second periods of life, the agent supplies L_0 and L_1 units of labor in return for market-determined wages, w_0 and w_1, respectively. Wage earnings are taxed at rate $\tau \in (0,1)$. In the first period, wage income is received with certainty, but in the second period there is some chance of unemployment, $p \in (0,1)$. The unemployment benefit $b > 0$ is received during second period if and only if unemployed.

Utility of the agent is affected by the own past consumption, as in a typical (internal) habit formation framework. Let current consumption be c_t. The reference stock of habit at time t, h_t, is determined as

$$h_t = \lambda h_{t-1} + (1-\lambda)c_{t-1}, \tag{1}$$

where h_0 is given, and $\lambda \in [0,1]$ measures the persistence of the habit process.[2] We deliberately do not consider habit in leisure since agents might be reluctant to adjust their work effort considerably in response to shocks.

Consequently,

$$h_1 = \lambda h_0 + (1-\lambda)c_0, \tag{2}$$

$$h_2 = \lambda h_1 + (1-\lambda)c_1. \tag{3}$$

The agent allocates first-period income between current consumption (c_0) and savings (s_0). Thus,

$$c_0 = (1-\tau)w_0 L_0 - s_0. \tag{4}$$

The agent anticipates a return $R_{t+1} > 1$ for his savings, and thus second period consumption (c_1)

[2]Note high λ implies that consumption in the distant past is difficult to forget.

can be presented as

$$c_1^{emp} = (1-\tau)w_1 L_1 + R_1 s_0 - s_1, \tag{5}$$

with probability $(1-p)$ (the agent is employed), and

$$c_1^{une} = b + R_1 s_0 - s_1, \tag{6}$$

with probability p (the agent is unemployed). Variable s_1 stands for second-period savings. It is reasonable to assume that $0 < b < \min\{(1-\tau)w_0 L_0, (1-\tau)w_1 L_1\}$. Last-period consumption is therefore

$$c_2 = R_2 s_1. \tag{7}$$

The instantaneous utility in any period t depends on consumption (c_t), the reference habit stock (h_t) and labor (L_t).

Remark 1. *Even a simple three-period model does not yield tractable, closed-form solutions unless we adopt some simplifying assumptions. Specifically, we assume habits take "subtractive" form in which utility is derived from the difference between current consumption and the habit stock, and we let $\lambda = 0$. In addition, we follow Sargent (1979), Christiano and Eichenbaum (1989), and West (1990), who assume that utility is separable over time, quadratic in consumption (in our case, consumption "difference"), and linear in leisure.*

Thus, let for $\phi > 0$ (a parameter that captures the strength of habit formation), the instantaneous utility function take the form

$$U_t(c_t, h_t, L_t) = \alpha_1(c_t - \phi h_t) - \frac{\alpha_2}{2}(c_t - \phi h_t)^2 - \beta L_t, \tag{8}$$

where α_1, α_2, β are positive. A common assumption is that a higher level of past consumption reduces the utility from current consumption, and increases the marginal utility of consumption today. In general, an increase in current consumption affects the current well-being, but also – via its influence on habit stock – future well-being. Therefore, larger values of ϕ imply that the agent receives less lifetime utility from a given level of spending. Consequently, to produce the same benefits, spending must be larger (Deaton, 1992; Dynan, 2000). In what follows, we require

$$\frac{\partial U_t}{\partial h_t} = -\phi\alpha_1 + \phi\alpha_2(c_t - \phi h_t) < 0, \tag{9}$$

$$\frac{\partial^2 U_t}{\partial c_t \partial h_t} = \phi\alpha_2 > 0. \tag{10}$$

If the agent works in the second period, his habit stock in the last period is

$$h_2^{emp} = c_1^{emp}, \tag{11}$$

while if he were unemployed in the second period, his habit stock in the last period is

$$h_2^{une} = c_1^{une}. \tag{12}$$

Consequently, assuming no discounting, the agent's problem is to

$$\begin{aligned} \max_{\{s_0,s_1,L_0,L_1\}} EU = {} & U_0(c_0, h_0, L_0) \\ & + (1-p)\{U_1(c_1^{emp}, h_1, L_1) + U_2(c_2, h_2^{emp}, 0)\} \\ & + p\{U_1(c_1^{une}, h_1, 0) + U_2(c_2, h_2^{une}, 0)\}. \end{aligned} \tag{13}$$

The first-order necessary conditions for an extremum produce the following optimal consumption and labor supply choices. Optimal first-period consumption is

$$c_0 = \frac{\beta\phi(R_2 + \phi) + R_1 R_2(\beta + w_0(\tau - 1)(\alpha_1 + h_0\alpha_2\phi))}{R_1 R_2 w_0 \alpha_2(\tau - 1)}. \tag{14}$$

When employed, second-period consumption is

$$c_1^{emp} = \frac{A_1 + A_2}{A_3 w_1(1 + \phi^2)}, \tag{15}$$

where

$$A_1 \equiv w_1\beta\phi((1 + \phi^2)^2 + R_2\phi(2 + \phi^2)), \tag{16}$$

$$A_2 \equiv R_1 R_2(w_1\beta\phi(1 + \phi^2) + w_0(\beta + w_1(\tau - 1)(1 + \phi^2)(\alpha_1 + \alpha_1\phi + h_0\alpha_2\phi^2))), \tag{17}$$

$$A_3 \equiv R_1 R_2 w_0 \alpha_2(\tau - 1). \tag{18}$$

When unemployed, second-period consumption is

$$c_1^{une} = \frac{R_2 A_4 + p(A_1 + A_2)}{p A_3 w_1(1 + \phi^2)}, \tag{19}$$

where

$$A_4 \equiv (w_1 - R_1 w_0)\beta. \tag{20}$$

Similarly, last-period consumption is

$$c_2 = \frac{A_5 + A_6}{A_3}, \tag{21}$$

where

$$A_5 \equiv \beta(1 + \phi^2 + \phi^4 + R_2(\phi + \phi^3)), \tag{22}$$

$$A_6 \equiv R_1 R_2(\beta\phi^2 + w_0(\tau - 1)(h_0\alpha_2\phi^3 + \alpha_1(1 + \phi + \phi^2))). \tag{23}$$

Turning to the optimal labor supply choices, the first-period labor supply becomes

$$L_0 = \frac{A_7 - p(A_8 + A_9 + R_1 R_2(A_{10} + A_{11}))}{pA_3 A_{14}}, \tag{24}$$

where

$$A_7 \equiv R_2^2(R_1 w_0 - w_1)\beta, \tag{25}$$

$$A_8 \equiv R_1^2 R_2^2 w_1(1 + \phi^2)(\beta + w_0(\tau - 1)(\alpha_1 + \alpha_2 h_0\phi)), \tag{26}$$

$$A_9 \equiv w_1\beta(1 + 2\phi^2 + 2\phi^4 + \phi^6 + 2R_2\phi(1 + \phi^2)^2 + R_2^2\phi^2(2 + \phi^2)), \tag{27}$$

$$A_{10} \equiv 2w_1\beta\phi(R_2 + \phi)(1 + \phi^2), \tag{28}$$

$$A_{11} \equiv w_0(R_2\beta + w_1(\tau - 1)(1 + \phi^2)(A_{12} - A_{13})), \tag{29}$$

$$A_{12} \equiv \alpha_1(1 + R_2 + \phi + R_2\phi + \phi^2), \tag{30}$$

$$A_{13} \equiv \alpha_2(R_2 b - h_0\phi^2(R_2 + \phi)), \tag{31}$$

$$A_{14} \equiv R_1 R_2 w_0 w_1(\tau - 1)(1 + \phi^2). \tag{32}$$

Finally, second-period labor supply becomes

$$L_1 = \frac{(w_1 - R_1 w_0)\beta - bpR_1 w_0 w_1\alpha_2(\tau - 1)(1 + \phi^2)}{pR_1 w_0 w_1^2\alpha_2(\tau - 1)^2(1 + \phi^2)}. \tag{33}$$

Remark 2. *It is straightforward to verify that the second-order condition holds at a stationary value of the objective function guaranteeing the stationary value to be a maximum. Appendix A outlines the details.*

Now let us turn into the comparative-static aspects of labor income taxation. Differentiating (33) with respect to the tax rate, we obtain

$$\frac{\partial L_1}{\partial\tau} = \frac{2(R_1 w_0 - w_1)\beta + bpR_1 w_0 w_1\alpha_2(\tau - 1)(1 + \phi^2)}{pR_1 w_0 w_1^2\alpha_2(\tau - 1)^3(1 + \phi^2)}. \tag{34}$$

Remark 3. *In a recessionary environment people expect that wages would tend to stagnate and even decline, so it is reasonable to assume that $w_1 \leq w_0$ during recessions. Similarly, during booms it is likely that $w_0 \leq w_1$. Furthermore, during recessions the probability of losing a job (p) is likely to be much higher than during expansions.*

Let us assume that higher tax rate somewhat stimulates the future labor supply, i.e., the sign of (34) is positive. Note that the first term in the numerator of (34) is definitely positive during recessions, while the second term is clearly negative irrespective of the state of the economy. Since the denominator of (34) is negative, an increase in the tax rate will stimulate the future labor supply if the probability of unemployment is sufficiently high, which is likely to be the case during recessions. To see this more clearly, let us differentiate (34) with respect to p, which leads to

$$\frac{\partial^2 L_1}{\partial\tau\partial p} = \frac{2(w_1 - R_1 w_0)\beta}{p^2 R_1 w_0 w_1^2 \alpha_2 (\tau - 1)^3 (1 + \phi^2)}. \tag{35}$$

Since the denominator of (35) is negative, it is clear that increasing the probability of unemployment will raise the positive effect of the tax rate on future labor supply, and this is more likely to be so during the recessionary environment when $w_1 < R_1 w_0$.

Remark 4. *Note that strength of habit formation (captured by parameter ϕ) does play a role in determining how the tax rate affects the labor supply, L_1. Namely,*

$$\frac{\partial^2 L_1}{\partial\tau\partial\phi} = \frac{2p\phi}{1+\phi^2}\frac{\partial^2 L_1}{\partial\tau\partial p}, \tag{36}$$

which is positive when (35) *is, and increases with the unemployment likelihood. Intuitively, since larger ϕ means less lifetime utility will be received for a given expenditure level, the agent, facing greater prospects of unemployment, plans to work even harder to be able to consume more.*

Turning to the first-period consumption choice, c_0, we obtain

$$\frac{\partial c_0}{\partial\tau} = -\frac{\beta(R_1 R_2 + \phi(R_2 + \phi))}{R_1 R_2 w_0 \alpha_2 (\tau - 1)^2}, \tag{37}$$

which indicates that the likelihood of unemployment does not impact how the current consumption rate responds to the tax rate. Expression (37) also clearly shows that higher taxes reduce current spending. Similar conclusions stem from the negative effect of the tax rate on the second-period spending if the agent is employed as

$$\frac{\partial c_1^{emp}}{\partial\tau} = \frac{\beta(R_1 R_2(w_0 + w_1\phi(1+\phi^2)) + w_1\phi((1+\phi^2)^2 + R_2\phi(2+\phi^2)))}{-R_1 R_2 w_0 w_1 \alpha_2 (\tau - 1)^2 (1+\phi^2)} \tag{38}$$

is strictly negative and does not depend on p. Analogously, higher taxes depress last period consumption as

$$\frac{\partial c_2}{\partial\tau} = -\frac{\beta(1 + \phi^2 + \phi^4 + R_2\phi(1 + R_1\phi + \phi^2))}{R_1 R_2 w_0 \alpha_2 (\tau - 1)^2}. \tag{39}$$

On the other hand, if the agent is unemployed in the second-period, the effect of the tax increase on his consumption is ambiguous as can be seen from the following expression

$$\frac{\partial c_1^{une}}{\partial \tau} = \frac{R_1 R_2((p-1)w_0 + pw_1(\phi+\phi^3)) + w_1(p\phi(1+\phi^2)^2 + R_2(1+p\phi^2(2+\phi^2)))}{-R_1 R_2 w_0 w_1 \alpha_2(\tau-1)^2(1+\phi^2)(p/\beta)}. \tag{40}$$

However, notice that

$$\frac{\partial^2 c_1^{une}}{\partial \tau \partial p} = \frac{(w_1 - R_1 w_0)\beta}{p^2 R_1 w_0 w_1 \alpha_2(\tau-1)^2(1+\phi^2)}. \tag{41}$$

Clearly, increasing the probability of unemployment will lower the effect of the tax rate on second period consumption when unemployed, particularly during recessions when $w_1 < R_1 w_0$. If higher taxes significantly depress first period and last period consumption, it is indeed possible that they might somewhat raise second-period consumption when unemployed, c_1^{une}. As can be seen from (41), higher values of p would make this effect less profound, becoming even smaller the stronger the habit formation parameter is.[3]

Finally, let us consider the effect of higher taxes on the current labor supply. We obtain

$$\frac{\partial L_0}{\partial \tau} = \frac{A_{14}(A_{15}+A_{16}) + \frac{2}{p}(A_7 - p(A_8 + A_9 + R_1 R_2(A_{10}+A_{11})))}{(1-\tau)A_3 A_{14}}, \tag{42}$$

where

$$A_{15} \equiv \alpha_1(1+\phi+\phi^2+R_2(1+R_1+\phi)), \tag{43}$$

$$A_{16} \equiv \alpha_2(-R_2 b + h_0\phi(R_1 R_2 + \phi(R_2+\phi))). \tag{44}$$

The sign of (42) is ambiguous. Note, however,

$$\frac{\partial^2 L_0}{\partial \tau \partial p} = -\frac{\partial^2 L_1}{\partial \tau \partial p}\frac{w_1}{w_0 R_1}. \tag{45}$$

Remark 5. *Recall that* (35) *being positive would make* (45) *negative. Suppose higher taxes increase future labor supply, but they reduce current labor supply. The net supply side effect is therefore unclear. However, since in recessionary environment, $w_1 < w_0 R_1$, it is clear from* (45) *that with higher probability of unemployment, the positive impact on higher taxes on L_1 will be more pronounced than the negative effect of higher taxes on L_0.*

[3]However, since expenditure of unemployed people is relatively small (and so is the share of unemployed in overall labor force), it is quite possible that the asymmetric positive labor supply effect discussed earlier would be dominant.

3 Data and Empirical Methodology

We obtain our data from a number of sources. The dependent variable is the percentage growth rate of output per worker (y_{it}), which is provided by the World Development Indicators (WDI). The main explanatory variables of interest are the tax measures. Statutory or top tax rates for corporate and labor taxes (top_corptax$_{it}$ and top_inctax$_{it}$, respectively) are obtained from the World Tax Database (http://www.bus. umich.edu/otpr/otpr/default.asp), which did not provide data beyond 2005. We were also engaged in extensive communications with the Finance Ministries in the OECD countries to confirm the data in the above database, as well as to find some of the missing data. The average tax rates are defined as the share of tax revenues of the respective tax group in the GDP (top_corptax$_{it}$ and top_inctax$_{it}$, respectively), and obtained from the OECD National Economic Outlook database. As Kneller et al. (1999) show the importance of controlling for the expenditure side while investigating the effects of the revenue side in empirical studies, we also adopt the natural log of government disbursements in GDP (G_{it}), in each and every regression, which was also obtained from OECD Economic Outlook database.

We use a number of control variables in the estimation in conjunction with the Cobb-Douglas production function approach used in the neoclassical growth models. Human capital is measured by natural logarithm of secondary school completion rate (HC_{it}) and provided by Barro and Lee (2013). The effects of population growth (Pop_{it}) are measured by the natural logarithm of labor force growth rate (provided by WDI).[4] Finally, we also control for the effects of saving and investment (I_{it}) by including the natural logarithm of investment as a percentage of GDP, also from WDI.

The following countries are included in our sample: Australia, Austria, Belgium, Canada, Germany, Denmark, Finland, France, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, UK and the USA. The time period covered in the study is 1981 to 2005. This panel yields 475 observations with few missing values.

Panel Smooth Transition Regression (PSTR, henceforth) allows for a small number of extreme regimes where transitions in-between are smooth (Gonzalez et al., 2017). We initially consider the simplest case with two extreme regimes:

$$\Delta y_{it} = \mu_i + \beta_0 x_{it} + \beta_1 x_{it} F(s_{it}; \gamma, c) + u_{it} \tag{46}$$

for $i = 1, \ldots, N$, and $t = 1, \ldots, T$, where N and T denote the cross-section and time dimensions of the panel, respectively. The dependent variable Δy_{it} is the growth rate of GDP for the 19 countries in our sample. The independent variables are in the k-dimensional vector x_{it}, and include investment (I_{it}), population (Pop_{it}), income tax (inc_{it}), corporate tax ($corp_{it}$), and, human capital (Hc_{it}). In addition, μ_i represents the individual (i.e., country) fixed effects, and finally u_{it} is the

[4] In particular, we add $+0:07$ to the population growth rate as a measure of depreciation rate. This also avoids negative numbers within the logarithms.

error term.

Transition function $F(s_{it};\gamma,c)$ is a continuous function of the observable variable s_{it}, which we call the state variable (in this particular case, growth). It is normalized to vary between 0 and 1 following in the footsteps of Gonzalez et al. (2017). Granger and Teräsvirta (1993) consider the following logistic and exponential transition function for the time series smooth transition models:

The two specifications generally considered for $F(s_{it};\gamma,c)$ are the logistic function:

$$F(s_{it};\gamma,c) = \frac{1}{1+\exp(-\gamma_l(s_{it}-c_l))/\sigma_{s_{it}}} \tag{47}$$

and the exponential function:

$$F(s_{it};\gamma,c) = (1-\exp\{-\gamma_E(s_{it}-C_E)^2/\sigma_{s_{it}}\}) \tag{48}$$

Here, the slope parameter γ determines how fast the transition is and the vector of location parameter c decides where the transition occurs. In cases where logistic function is used, the low and high values of s_{it} correspond to the two extreme regimes. The steps used in the estimation are first outlined in Gonzalez et al. (2017).

Linearity (homogeneity) tests are important for estimating PSTR models which contain unidentified nuisance parameters. To overcome this problem, we replace the transition function $F(s_{it},\gamma,c)$ by its first order Taylor expansion around $\gamma=0$ (Luukkonen et al., 1988). This, in turn, gives us the following equation

$$\Delta y_{it} = \mu_i + \beta_0^{'*}x_{it} + \beta_1^{'*}x_{it}s_{it} + \cdots + \beta_1^{'*}x_{it}s_{it}^m + u_{it}^* \tag{49}$$

We test the joint significance of the parameters of (49) by using the following LM test-statistic:

$$LM_F = \frac{(SSR_0 - SSR_1)/mk}{SSR_0/(TN-N-m(k+1))} \tag{50}$$

with an approximate distribution of $F(mk, TN-N-m(k+1))$. Then, following Gonzalez et al. (2017), we choose between logistic and exponential transition functions, we apply sequential conditional F-tests.

Once the transition variable and form of the transition function are selected, one can estimate the PTSR model by using non-linear least squares (NNLS). The starting values for the NNLS are obtained from a two dimensional grid search over γ and c for the estimates that minimize the panel sum of squared residuals.

To remedy a possible cross section dependency problem, we follow Omay and Kan (2010) who propose the nonlinear version of the common correlated effect (CCE) estimator:

$$y_{it} = \mu_i + \beta x_{it} + F(s_{it}, \gamma, c)\tilde{\beta}' x_{it} + u_{it} \tag{51}$$

where

$$\begin{aligned} F(s_{it}, \gamma, c) &= \frac{1}{1 + e^{-\gamma(s_{it} - c)}}, \\ u_{it} &= \varphi_t f_t + \varepsilon_{i,t}, \\ x_{it} &= \delta_i \tilde{f}_t + \nu_{it} \end{aligned}$$

They obtained following the auxiliary regression:

$$y_{it} = \tilde{\mu}_i + \beta' x_{it} + F(\cdot)\tilde{\beta}' x_{it} + a\bar{y}_t + b\bar{x}_t + \bar{F}(\cdot)c\bar{x}_t + \eta_{it} \tag{52}$$

where $\tilde{\mu} = \tilde{\mu} - \frac{\varphi}{\bar{\varphi}}\bar{\mu}$, $b = \frac{\varphi\bar{\beta}}{\bar{\varphi}}$, $a = \frac{\varphi}{\bar{\varphi}}$, $c - \frac{\varphi\bar{\tilde{\beta}}}{\bar{\varphi}}$, and $\eta_{it} = \varepsilon_{it} - \frac{\varphi}{\bar{\varphi}}\bar{\varepsilon}_t$.

Now we can estimate the models by this transformation in order to eliminate the cross-section dependency.

4 Empirical Results

4.1 Top Tax Rates: Corporate and Labor

Our results show that, consistent with the majority of the previous literature, corporate taxation is harmful for economic growth. In particular, using the top statutory tax rate a la Lee and Gordon (2005), we find that corporate taxes are distortionary for growth in high-growth and low-growth periods (Model 1). More specifically, a one-percentage point increase in the top corporate tax rate decreases growth by 0.58 percent in low-growth regimes and 0.73 percent in high-growth regimes. Importantly, our coefficient estimates are much larger than those reported by Lee and Gordon (2005). The discrepancy between the magnitudes of the coefficients may be pointing out the importance of non-linear relationship between economic growth and the fiscal variables. Another explanation for this discrepancy could be the difference in sample countries- as our sample includes the OECD countries only.

On the other hand, our results show that labor taxes are distortionary for growth only during high-growth periods (Model 1). Our coefficient estimate shows that a one-percentage point increase in the top-labor tax rate decreases growth by 0.27 percent. This result is quite different than Lee and Gordon (2005), who report no significant effect of labor tax on economic growth. It is interesting to see that both corporate tax and labor tax multipliers are larger in high growth regimes. This result is in line with Sims and Wolff (2018) who show that a tax rate cut is most stimulative for output in periods in which output is higher.

4.2 Average Taxes: Corporate and Labor

We next use the average tax rate for corporate and labor to measure the fiscal policy a la Kneller et al. (1999). Our estimations point to largely similar results as above. In particular, we find that a one-percentage point increase in average corporate tax rate decreases the growth rate by 0.12 percent in low-growth regimes and 0.07 percent in high-growth regimes (Model 2). Though the magnitude of coefficients are smaller in this case, our result provides further evidence that corporate taxes are harmful for economic growth in both states of the world. However, it is evident that the distortionary effects of taxation may be better identified through statutory rates, given the larger magnitude of estimated coefficients.

Proceeding to average labor taxes, we find that labor taxes exert a significant effect on growth only in high-growth regime (Model 2). In particular, our coefficient estimate shows that a one-percentage point increase in average labor tax rate decreases economic growth by 0.07 percent. Importantly, these estimates are lower than those reported by Kneller et al. (1999). This particular result is not surprising as Kneller et al. (1999) use average rate for distortionary taxes which include both income and corporate taxes, while we look into those two groups separately. An interesting finding is the coefficient for government expenditures, which is negative and significant – a result consistent with the "Non-Keynesian Effects" of fiscal policy (Alesina et al., 2002).

5 Concluding Remarks

The relationship between taxation policy and economic growth has been hotly debated in the literature. While there exists by and large a consensus on the adverse effects of corporate taxes on economic growth, the role played by labor taxes in the course of growth is yet to be understood. The primary gap in the knowledge has been related to the ways in which labor taxes influence economic growth in the presence of non-linearities, that is, during the expansionary vs recessionary states of the economy. This paper takes a two-pronged approach to the problem, whereby the first step builds a theoretical model to illuminate the connection between labor taxation and economic growth, taking into account the state of the economy, and the second step undertakes an empirical analysis utilizing a rich data set from 19 OECD countries on statutory and average tax rates over the period 1981-2005.

Our theoretical model demonstrates that labor taxes have dissimilar distortionary effects on economic growth depending on the state of the economy. In particular, while taxes on labor income can be harmful during the high-growth regime, their effect can be insignificant during the low-growth regime. The key intuition behind this result is that during recessions, people expect higher chances of becoming unemployed. This channel, reinforced with the fact that consumers might form habits in their expenditure patterns, leads to a greater labor supply response when individual wage income taxes rise.

Our empirical analysis sheds more light on the tax rate-economic growth puzzle. Featuring an advanced panel non-linear estimation technique, the Panel Smooth Transition model, which enables accounting for non-linearities in the tax structure-economic growth relationship, our findings show that while corporate taxes are distortionary regardless of the growth regime, taxes on labor income are harmful for growth only during the high-growth regimes.

According to OECD estimates, Tax-to-GDP ratios fell in a majority of OECD countries between 2007 and 2011 while the share of tax revenue from income and profits decreased by 2.5 percentage points. Bearing this in mind (and the fact that fiscal stimulus is often needed in low-growth periods), our findings suggest that governments might choose to rely more on corporate tax cuts to stimulate the economy. Our results once again highlight the importance of non-linearities in the fiscal policy-growth nexus. Needless to say, future research may investigate how different types of government spending affect economic growth taking into account these non-linearities.

References

Christopher S Adam and David L Bevan. Fiscal deficits and growth in developing countries. *Journal of Public Economics*, 89(4):571–597, 2005.

Alberto Alesina, Silvia Ardagna, Roberto Perotti, and Fabio Schiantarelli. Fiscal policy, profits, and investment. *American Economic Review*, 92(3):571–589, 2002.

K Peren Arin, Michael Berlemann, Faik Koray, and Torben Kuhlenkasper. Nonlinear growth effects of taxation: A semi-parametric approach using average marginal tax rates. *Journal of Applied Econometrics*, 28(5):883–899, 2013.

Robert J Barro. Economic growth in a cross section of countries. *The quarterly journal of economics*, 106(2):407–443, 1991.

Robert J Barro and Jong-Wha Lee. A new data set of educational attainment in the World, 1950-2010. *Journal of Development Economics*, 104:184–198, 2013.

Lawrence J Christiano and Martin Eichenbaum. Temporal aggregation and the stock adjustment model of inventories. In T Kollintzas, editor, *The Rational Expectations Equilibrium Inventory Model*, volume 322, pages 70–108. Springer, New York, NY, 1989.

Angus Deaton. *Understanding Consumption*. Oxford University Press, Oxford, 1992.

Karen E Dynan. Habit formation in consumer preferences: Evidence from panel data. *American Economic Review*, 90(3):391–406, 2000.

William Easterly and Sergio Rebelo. Fiscal policy and economic growth: An empirical investigation. Working Paper 4499, NBER, 2002.

A Gonzalez, Timo Teräsvirta, Dick Van Dijk, and Yukai Yang. Panel smooth transition regression models. Working paper, Stockholm School of Economics, 2017.

Clive WJ Granger and Timo Teräsvirta. Modelling non-linear economic relationships. *OUP Catalogue*, 1993.

Richard Kneller, Michael Bleaney, and Norman Gemmell. Fiscal policy and growth: Evidence from OECD countries. *Journal of Public Economics*, 74:171–190, 11 1999.

Young Lee and Roger H Gordon. Tax structure and economic growth. *Journal of Public Economics*, 89(5):1027–1043, 2005.

Robert E Lucas. Supply-side economics: An analytical review. *Oxford Economic Papers*, 42(2): 293–316, 1990.

Ritva Luukkonen, Pentti Saikkonen, and Timo Teräsvirta. Testing linearity against smooth transition autoregressive models. *Biometrika*, 75(3):491–499, 1988.

Enrique Mendoza, Gian Maria Milesi-Ferretti, and Patrick Asea. On the ineffectiveness of tax policy in altering long-run growth: Harberger's superneutrality conjecture. *Journal of Public Economics*, 66(1):99–126, 1997.

Karel Mertens and Morten O Ravn. The dynamic effects of personal and corporate income tax changes in the United States. *American Economic Review*, 103(4):1212–47, 2013.

Tolga Omay and Elif Öznur Kan. Re-examining the threshold effects in the inflation–growth nexus with cross-sectionally dependent non-linear panel: Evidence from six industrialized economies. *Economic Modelling*, 27(5):996–1005, 2010.

Hashem M Pesaran. Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, 74(4):967–1012, 2006.

Thomas J Sargent. *Macroeconomic Theory.* Academic Press, New York, NY, 1979.

Eric Sims and Jonathan Wolff. The state-dependent effects of tax shocks. *European Economic Review*, 107:57–85, 2018.

Robert Solow. A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70(1):65–94, 1956.

TW Swan. Economic growth and capital accumulation. *Economic Record*, 32(2):334–361, 1956.

Timo Teräsvirta. Specification, estimation, and evaluation of smooth transition autoregressive models. *Journal of the American Statistical Association*, 89(425):208–218, 1994.

Timo Teräsvirta and HM Anderson. Characterizing nonlinearities in business cycles using smooth transition autoregressive models. *Journal of Applied Econometrics*, 7(S1):119–136, 1992.

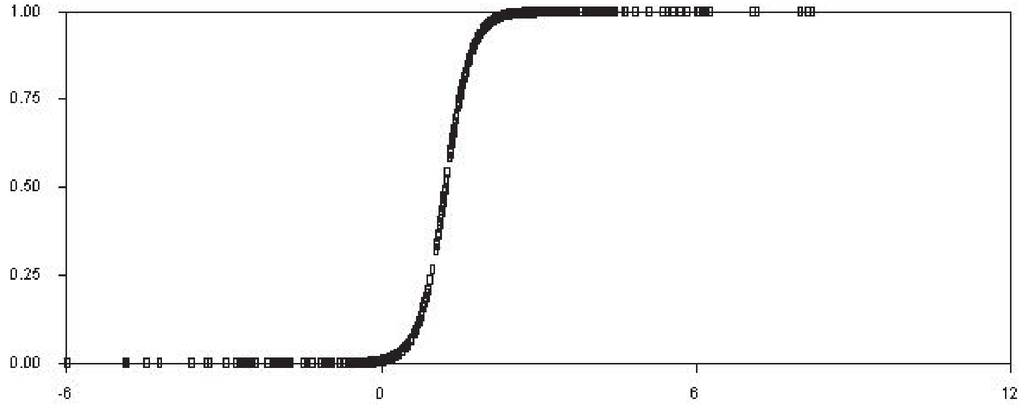
Kenneth D West. The sources of fluctuations in aggregate inventories and GNP. *Quarterly Journal of Economics*, 105(4):939–971, 1990.

Table 1: Estimation Results of Two-Regime PSTR Models with Pool Common Correlated Effect

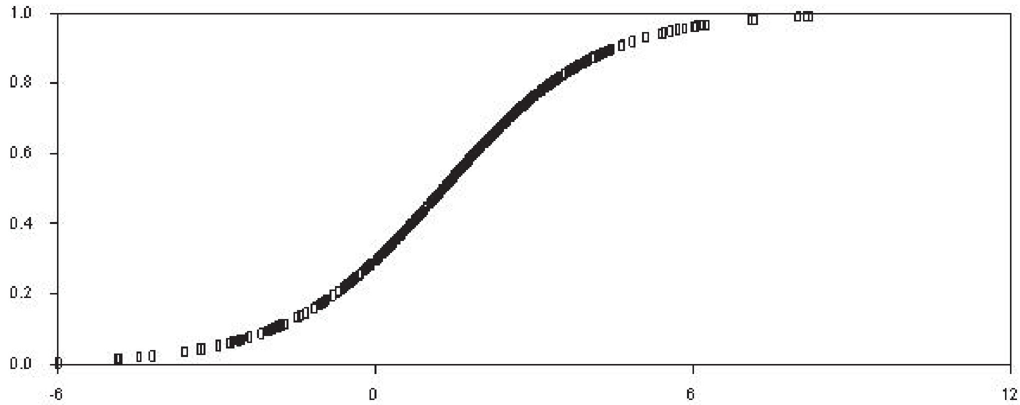
	(1)	(2)
Dependent variable	Δy_{it}	Δy_{it}
Low Growth Periods		
HC_{it}	-0.058	-0.059
	(-0.132)	(-0.702)
Pop_{it}	-1.675	-0.006
	(-1.498)	(-1.054)
In_{it}	1.166	0.112
	(1.151)	(1.339)
G_{it}	-3.129^{*}	-0.078
	(-2.755)	(-0.262)
top_corptax_{it}	-0.582^{***}	
	(-1.673)	
top_inctax_{it}	0.148	
	(1.424)	
corptax_{it}		-0.122^{*}
		(-2.553)
labtax_{it}		-0.174
		(-0.883)
High Growth Periods		
HC_{it}	0.271	-0.198
	(0.847)	(-0.221)
Pop_{it}	0.881	-0.006
	(0.689)	(-0.493)
In_{it}	-0.714	0.152^{*}
	(-0.645)	(2.433)
G_{it}	-2.268^{*}	-0.056
	(-2.669)	(-0.839)
top_corptax_{it}	-0.733^{**}	
	(-1.946)	
top_inctax_{it}	-0.276^{*}	
	(-2.268)	
corptax_{it}		-0.067^{***}
		(-1.649)
lab_{it}		-0.069^{*}
		(-2.185)
Threshold	1.203^{*}	1.818^{*}
	(33.799)	(21.158)
Gamma	98.014	10.143
	(1.012)	(1.234)

(*) %1 significance level, (**) %5 significance level, (***) %significance level.

** The values in the parentheses are t values.



(a) Model 1



(b) Model 2

Figure 1: The transition functions for model 1 and 2

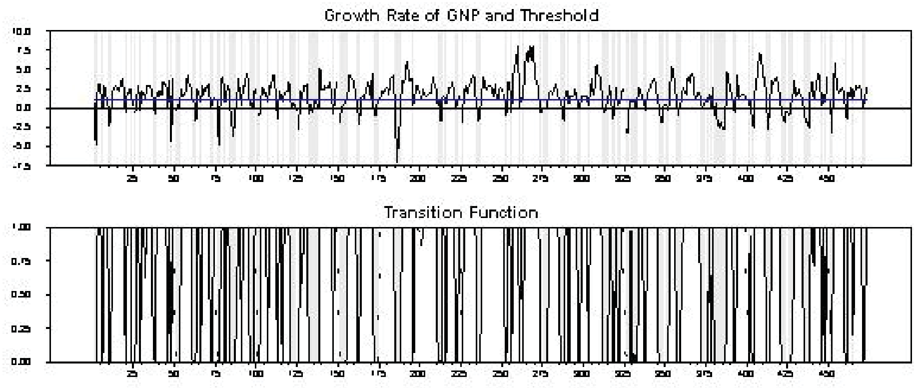


Figure 2: Transition function with respect to time and threshold value for the first model

A Appendix

The Hessian matrix of expected utility function given by (13)

$$H = \begin{bmatrix} h_{11} & h_{12} & h_{13} & h_{14} \\ h_{21} & h_{22} & h_{23} & h_{24} \\ h_{31} & h_{32} & h_{33} & h_{34} \\ h_{41} & h_{42} & h_{43} & h_{44} \end{bmatrix}, \tag{A1}$$

where

$$h_{11} \equiv -\alpha_2(1 + 2R_1\phi + \phi^2 + R_1^2(1 + \phi^2)), \tag{A2}$$
$$h_{12} \equiv \alpha_2(\phi + R_1(1 + R_2\phi + \phi^2)), \tag{A3}$$
$$h_{13} \equiv w_0\alpha_2(1 - \tau)(1 + R_1\phi + \phi^2), \tag{A4}$$
$$h_{14} \equiv w_1\alpha_2(1 - p)(\tau - 1)(R_1 + \phi + R_1\phi^2), \tag{A5}$$
$$h_{22} \equiv -\alpha_2(1 + R_2^2 + 2R_2\phi + \phi^2), \tag{A6}$$
$$h_{23} \equiv w_0\alpha_2(\tau - 1)\phi, \tag{A7}$$
$$h_{24} \equiv w_1\alpha_2(p - 1)(\tau - 1)(1 + R_2\phi + \phi^2), \tag{A8}$$
$$h_{33} \equiv -w_0^2\alpha_2(\tau - 1)^2(1 + \phi^2), \tag{A9}$$
$$h_{34} \equiv (1 - p)w_0w_1\alpha_2(\tau - 1)^2\phi, \tag{A10}$$
$$h_{44} \equiv (p - 1)w_1^2\alpha_2(\tau - 1)^2(1 + \phi^2), \tag{A11}$$

and $h_{21} = h_{12}$, $h_{31} = h_{13}$, $h_{32} = h_{23}$, $h_{41} = h_{14}$, $h_{42} = h_{24}$, $h_{43} = h_{34}$. Since the four principal minors of H given by

$$-\alpha_2(1 + 2R_1\phi + \phi^2 + R_1^2(1 + \phi^2)), \tag{A12}$$
$$\alpha_2^2(1 + \phi^2 + \phi^4 + 2R_2\phi(1 + R_1\phi + \phi^2) + R_2^2(1 + R_1^2 + 2R_1\phi + \phi^2)), \tag{A13}$$
$$-R_1^2R_2^2w_0^2\alpha_2^3(\tau - 1)^2, \tag{A14}$$
$$(1 - p)pR_1^2R_2^2w_0^2w_1^2\alpha_2^4(\tau - 1)^4(1 + \phi^2), \tag{A15}$$

respectively, duly alternate in sign, the solution to (13) is a maximum.