Average Tax Rates and Economic Growth: A NonLinear Causality Investigation for the USA

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Abstract

This study uses a nonlinear causality test proposed by Diks and Panchenko (2006) to investigate the dynamic nonlinear relationship between economic growth and taxation, the later being expressed in the form of two alternative average tax rates, namely the ratio of total tax revenues to GDP and, the ratio of taxes less subsidies on production and imports to GDP for the USA. The empirical evidences reveal the existence of a nonlinear bilateral causality running from both tax rates to per capita GDP growth and vice versa. The findings support empirically the endogenous growth theoretical underpinning that taxes can affect economic growth in a dynamic way. However, using tax rates as a single fiscal policy instrument, particularly in times of recession, could cause uncontrollable and unfavourable changes in both economic growth and collected tax revenues.

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1 - Introduction and literature review

Our empirical investigation departs from the endogenous growth theorists' claim of a permanent influence of taxes on output growth. Specifically, the present empirical study is focused on the nonlinear relation between tax rates and output growth as indicated in the theoretical AK model in Barro (1990). This model considers an economy populated by households and firms and discusses an output growth constrained maximization problem with a theoretical nonlinear and evidently concave output growth maximization function[1].

A survey of the extensive theoretical and empirical literature reveals that there is much controversy regarding the nature and the direction of causality between economic growth and taxation. Moreover, the role of taxes as determinants of the output growth has not been conclusively supported by the empirical literature in the taxes-growth nexus.

In this area of literature, there are numerous studies employing an ample variety of models and methodologies (e.g. linear vs. nonlinear models, parametric vs. nonparametric models, time series vs. panel data models, etc.) to determine the correlation and investigate the causality between GDP growth and tax rates. A large part of the empirical studies in this field, either conclude that there is no correlation between tax rates and GDP growth, or attribute the role of GDP growth determinants solely to marginal tax rates.[2]

In this study, the main hypothesis tested is whether there exists a bilateral nonlinear dependence between average tax rates[3] and economic growth for the USA. A minor hypothesis tested as well is whether causality flows change with the level of disaggregation in average tax rates, as some recent empirical studies in this field seem to conclude.

Recently, Karagianni et al. (2012) investigated the non-linear causality among tax burden distribution and per capita GDP growth. In a fiscal policy framework, the study reveals the GDP growth influential role of the tax burden distribution across tax-liable groups in the USA economy.

The contribution of this study to the existing empirical literature lies in the empirical illustration-for the case of the USA-of the bilateral nonlinear

[1] For details in the theoretical considerations of the output growth constrained maximization problem, refer to Barro (1990).

[2] Some indicative studies in this area are: King and Rebelo (1990), Barro (1991), Plosser (1992), Easterly and Rebelo (1993), Barro and Sala-i-Martin, (1995), De la Fuente (1997), Angelopoulos et al. (2007), etc.

[3] In the framework of the empirical analysis in this paper, the ratios of tax revenues over GDP are considered equivalent to average tax rates and explored econometrically as rates.

relationship between the country's average tax rates (both at aggregate and disaggregated level) and the output growth. The nonlinear relationship between tax rates and output growth was first introduced by the theoretical AK endogenous growth model in Barro (1990). However, the theoretical considerations of the above pivotal study have not been adequately documented thereafter in the field empirical literature. This study declares omitted nonlinearity as the factor that might have caused the widespread diversification of the empirical findings in the field literature. Our research moves beyond the linear causality tests because of the inability they exhibit to discover dynamic economic growth dependencies. In fact, the presence of linear causality does not necessarily exclude the existence of nonlinear dynamic dependences [see Kyrtsou and Labys (2006)]. Subsequently, the construction of economic growth models, simply by building over an evident linear causality between economic growth and tax rates could be misleading. In our case, overlooking hidden nonlinear dynamic dependences between economic growth and tax policy could deter a model's economic growth determining power and forecasting credibility. Furthermore, the study illustrates that, considering tax rates as a single fiscal policy instrument might bring in unforeseen and non-proportional effects on economic growth and tax revenues.

For the purposes of our study, we have applied a more recent nonlinear and nonparametric causality test, that of Diks and Panchenko (2006) instead of the frequently used Hiemstra-Jones (1993, 1994) test which is a modified version of Baek and Brock (1992). Diks and Panchenko (2006) argue that the Hiemstra-Jones nonlinear causality test may be inconsistent due to the factor heteroskedasticity that causes over rejection of the null hypothesis of no causality. The new nonparametric Granger causality test proposed by Diks and Panchenko (2006) is used here to diminish that bias.

The paper is organised as follows: Section 2 presents the nonparametric Diks-Panchenko causality test, section 3 describes the data and the empirical results, and section 4 concludes.

2 - The nonparametric Diks-Panchenko causality test

In 1969, Granger proposed a causality test to describe the dependence relations between economic time series. According to this, if two variables $\{X_t, Y_t, t \geq 1\}$ are strictly stationary, $\{Y_t\}$ Granger causes $\{X_t\}$ if past and/or current values of X contain additional information on future values of Y.

Suppose that $\mathbf{X}_t^{l_X} = (X_{t-l_X+1},\ldots, X_t)$ and $\mathbf{Y}_t^{l_Y} = (Y_{t-l_Y+1},\ldots, Y_t)$ are the delay vectors - where l_X, $l_Y \geq 1$. Diks and Panchenko (2006) examine the null hypothesis that past observations of $\mathbf{X}_t^{l_X}$ contain any additional information about Y_{t+1} (beyond that in $\mathbf{Y}_t^{l_Y}$):

$$H_0: \; Y_{t+1} \mid (\mathbf{X}_t^{l_X}; \mathbf{Y}_t^{l_Y}) \sim Y_{t+1} \mid \mathbf{Y}_t^{l_Y} \qquad (1)$$

The test statistic can be represented by the following equation:

$$T_n(\varepsilon_n) = \frac{n-1}{n(n-2)} \cdot \sum_i (\hat{f}_{X,Z,Y}(X_i, Z_i, Y_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i)\hat{f}_{Y,Z}(Y_i, Z_i)) \qquad (2)$$

where, $f_{X,Y,Z}(x,y,z)$ is the joint probability density function. For $l_X = l_Y = 1$ and if $\varepsilon_n = Cn^{-\beta}(C > 0, \frac{1}{4} < \beta < \frac{1}{3})$, Diks and Panchenko (2006) prove that the test statistic in equation (2) satisfies the following:

$$\sqrt{n}\frac{(T_n(\varepsilon_n) - q)}{S_n} \xrightarrow{D} N(0,1) \qquad (3)$$

where $\xrightarrow{D}$ denotes convergence in distribution and S_n is an estimator of the asymptotic variance of $T_n(\cdot)$ [Diks and Panchenko (2006), Bekiros and Diks (2008)]. In this study, following the Diks and Panchenko's suggestion, we implement a one-tailed version of the test.

3 - Data and empirical results

3.1 - Data and preliminary analysis

The data used in this study are quarterly, seasonally adjusted at annual rates and cover the time period 1964:1 to 2007:2 for the USA. GDPN stands for the Gross Domestic Product per capita in current prices. The variable GDPN is expressed in natural logarithms and has been interpreted in growth terms after taking the first differences on per capita GDP (DLGDPN). The tax rate PTGDP results from the revenue data of total government taxes less subsidies on production and imports by GDP and the tax rate TTGDP results from the national total state and local tax revenue by GDP. Data for total government taxes less subsidies on production and imports and GDP are

obtained from the *OECD Quarterly National Accounts Statistics* while, data on national total state and local tax revenue are obtained from the *US Census Bureau Quarterly Tax Reports* and finally, population data are drawn from IMF's *WEO databases.* All data used are expressed in current prices[4]. The tax series used in the test are in first difference changes. The use of the Diks-Panchenko nonlinear causality test is justified by the presence of high kurtosis value (see table 1), suggesting heteroskedasticity structures in data sets [Diks and Panchenko (2006)].

Table 1: Descriptive statistics of the data

	DPTGDP	DTTGDP	DLGDPN
Mean	-0.0000692	0.000104	0.015095
Standard Deviation	0.000926	0.001753	0.009733
Kurtosis	6.361581	51.57016	4.615081
Skewness	-0.360447	-0.731073	0.562097

3.2 - Nonlinear causality results

In order to test for nonlinear causality, we first need to remove linear dependence. In particular, we estimate the following VAR model with the two tax rate variables and the growth rate:

$$\mathbf{X}_t = a_{11}X_{t-1} + a_{12}X_{t-2} + \beta_{11}Y_{t-1} + \beta_{12}Y_{t-2} + \varepsilon_t \qquad (4)$$
$$\mathbf{Y}_t = a_{21}X_{t-1} + a_{22}X_{t-2} + \beta_{21}Y_{t-1} + \beta_{22}Y_{t-2} + u_t$$

where t=1,2,…, T, a_{11}, β_{11}, …. etc. are the coefficients of the lagged variables and ε_t and u_t are white-noise error terms. With means of the BIC criterion, two lags are chosen.

The nonlinear Diks-Panchenko causality test is applied to the estimated residual series of the VAR model. Table 2a presents the results of the nonlinear causality test between the production tax rate and GDP growth, while Table 2b reports those between the aggregate tax rate and GDP growth. The test has been applied for l_X= l_Y=1…5 and ε_n=1.5, set according to the time series length n[5].

[4] Converting current prices to constant ones could induce distortions due to the nonlinear nature of the underlying data generating mechanism.

[5] The lag lengths l_X and l_Y are ranged between 1 and 5 and not between 1 and 8 as in the case of Hiemstra and Jones test. In that way, the rejection rate decreases with $l_X = l_Y$, so that the risk of

Table 2a: NonLinear Causality Test (DPTGDP and DLGDPN) (sample period 1964:1 to 2007:2)

	DPTGDP → DLGDPN		DLGDPN → DPTGDP	
Lx=Ly	T statistics	p-value	T statistics	p-value
1	1.535	0.06242**	1.598	0.05502**
2	1.830	0.03362*	1.667	0.04773*
3	1.464	0.07154**	1.340	0.09006**
4	1.713	0.04331**	1.196	0.11589
5	1.136	0.12792	0.418	0.33811

Note: The null hypothesis suggests that DPTGDP does not cause DLGDPN and DLGDPN does not cause DPTGDP, respectively. *(**) denotes *p*-value statistical significance at 5% (10%) level.

Table 2b: NonLinear Causality Test (DTTGDP and DLGDPN) (sample period 1964:1 to 2007:2)

	DTTGDP → DLGDPN		DLGDPN → DTTGDP	
Lx=Ly	T statistics	p-value	T statistics	p-value
1	1.470	0.07075*	1.418	0.07814*
2	1.236	0.10830	1.361	0.08679*
3	1.444	0.07436*	1.293	0.09806*
4	1.311	0.09500*	0.749	0.22702
5	1.177	0.11954	0.425	0.33536

Note: The null hypothesis suggests that DTTGDP does not cause DLGDPN and DLGDPN does not cause DTTGDP, respectively. * denotes *p*-value statistical significance at 10% level.

Looking at the empirical findings, bidirectional causality is detected between average tax rates to GDP growth. As table 2a indicates there is evidence for a nonlinear feedback between DPTGDP and DLGNPN since the test statistics is statistically significant for either 5% or 10% in more than a half of cases regarding the selected delays. The findings also provide support for the existence of a bidirectional nonlinear causal relationship between

rejecting under the null becomes small. Besides, instead of using ad-hoc values for ε_n, in the Diks and Panchenko test, ε_n depends on the sample of the data and it is equal to Max($C^{n-2/7}$, 1.5), where n is the number of observations and C an optimal constant. More details on the use of delays l_X , l_Y and the bandwidth ε_n can be found in Diks and Panchenko (2006).

DTTGDP and DLGNPN, with 1, 3 and 4 lags in the flow running from DTTGDP to DLGNPN and with lags 1, 2 and 3 in the flow running in the opposite way (Table 2b). Evidently, the nonlinear causality flow running from PTGDP to GDP growth is slightly stronger compared to that of the TTGDP.

The apparent nonlinear causality running from both average tax rates to GDP growth means that, taxation could be a policy instrument in stimulating USA economic growth, of questionable effectiveness though, due to the inexplicit way that economic growth is affected. Moreover, the reverse nonlinear causality from GDP growth to average tax rates uncovers a non-proportional tax burden reallocation triggered by the economic growth changes that further complicates the dynamics of the GDP growth-taxation relationship. A likely reasoning of the above finding could be the uneven contribution of the different economic activities to the economic development, the hidden economy, the discriminative tax treatment of various economic sectors and agents, inefficiencies in tax enforcement process, etc. Thus, it is not surprising for policy makers and regulators to fail when they seek to detect *ex ante* the economic growth effects caused by a shock in taxation.

4 - Conclusions and policy considerations

In this paper, we investigated the existence of nonlinear causality between two alternative average tax rates - namely the aggregate tax rate and the production tax rate - and economic growth for the period 1964:1 to 2007:2 in the USA.

The findings offer some interesting policy considerations and provide hints for future research in the economic growth-tax policy nexus. The nonlinear causality testing approach employed in this study, uncovers the nonlinear high power causal dependence of the USA GDP growth and average tax rates. The findings suggest that an appropriate field empirical analysis should consider empirical modalities to account for the nonlinear dynamics in the tax rates-GDP growth-relationship. The existing nonlinearity decreases predictability and risks any attempt for accurate *ex ante* estimations of anticipated effects of a shock in taxation (e.g. when increasing tax rates in anticipation of an increase of the public revenues) to the economic growth (of the USA in this case). To some extend, this explains the low forecasting performance of many linear, empirical models in the field literature. The findings support also the argument that what actually hinders a successful empirical modelling attempt in this field, may not be the appropriateness of

the average tax rates when used as policy variables in the modelling process, but instead, it is the highly complex dependence dynamics between the average tax rates and the output growth.

As regards the more persistent causality flow over economic growth in the case of the production and imports tax revenues ratio compared to the total tax revenues ratio, this could be explained by the aggregation level of the examined series. The findings underscore the prominent causal link between the tax measures imposed on production and imports, and economic growth. Instead, when tax revenues are deemed at an aggregate level (i.e. as an outcome of tax measures on corporate income, personal income, etc.) then, inevitably a variety of largely differentiated effects on economic growth, is accounted.

Summing up, the use of tax rates as a single fiscal policy tool, is perhaps simplistically perceived as a '*convenient*' and '*an-one-size-fits-all*' policy instrument, since an appropriate use would also call for a careful consideration of an economy's cycle and adequate support by additional policy instruments (e.g. structural and institutional reforms).[6] As it is pointed out by Kyrtsou and Labys (2006), in the presence of "…complex structure …, policies focusing only on one economic variable are condemned to fail. On the contrary, multi-dimensional policies, i.e. policies that take into account a set of economic variables, can be more flexible and consequently efficient, in the sense that they will have higher probabilities of minimizing deviations from their final policy objective".

Future research could explore the role of individual economies and large scale economic shocks in the growth-taxes nonlinear causality relationship.

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