CAUSALITY BETWEEN TAXES AND EXPENDITURES IN THE U. S.: A MULTIVARIATE APPROACH

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ABSTRACT

Applying Hsiao's version of the Granger causality method, this paper reexamines the causality between nominal expenditures and revenues in the United States for the 1946-96 period in a multivariate framework. Both the Engle-Granger two-step and Johansen canonical cointegration tests are performed. This study finds that taxes, spending, and GDP are cointegrated. While this study detects no evidence of causality between revenues and expenditures, it is found that income causes both revenues and expenditures in the Granger sense in the United States.

I. INTRODUCTION

Whether changes in tax revenues affect government expenditures (or vice versa) has been an issue of heated debate among economists as well as public policy makers. In the literature there are four models of public finance that characterize the relationship between taxes and expenditures.

First, in the spend-and-tax hypothesis, the political system somehow determines how much to spend and then looks for revenue sources to finance the spending (Barro, 1974; Peacock and Wiseman, 1979; Anderson et al., 1986). Second, there is the tax-and-spend proposition championed by Friedman (1978) and Buchanan and Wagner (1977). Friedman (1978) argues that increasing taxes results in more spending, thus causing a larger deficit. However, Buchanan and Wagner (1977) contend that politicians often choose debt financing over tax financing, thereby distorting the tax-and-spend prediction. Thus, to Friedman, lower taxes may lead to lower expenditures while to Buchanan and Wagner, lower taxes do not necessarily always suggest smaller spending because the government can borrow and spend (see Lee and Vedder, 1992). Third, in the tax-and-spend and spend-and-tax scenario, Musgrave (1966) and Meltzer and Richard (1981) argued that government may change expenditures and taxes simultaneously. The fourth model is the argument that because of the institutional separation of the allocation and taxation functions of government what happens to one can not affect the behavior of the other.

In the empirical literature, the relationship between taxes and expenditures is as controversial as in the theoretical literature. In their studies for the U.S., Von Furstenberg, et al. (1985) and Anderson et al. (1986), Provopoulos and Zambaras (1991) and Hondroyiannis and Papapetrou (1996) found that expenditures cause taxes. On the other hand, Manage and Marlow (1986) found a bidirectional causality for the U.S. Ram (1988) reexamined this issue and found that revenues cause expenditures at the federal level, whereas expenditures cause revenues at state and local levels in the United States. Joulfaian and Mookerjee (1990) and Hasan and Lincoln (1997) found support for both the tax-and-spend and the spend-and-tax hypotheses at the federal level.

Using the recently developed technique of cointegration with the aid of error-correction modeling, Miller and Russek (1990), Bohn (1991), and Jones and Joulfaian (1991) found causality running unidirectionally from expenditures to revenues in the short run, but discerned feedback between the two

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in the long run. Most recently, Owoye (1995) reexamined data for the G7 countries and found feedback causality in the U.S., Germany, the UK, France, and Canada, but identified causality from taxes to expenditures in Japan and Italy. Thus, the literature review reveals mixed and inconclusive evidence concerning the relationship between government expenditures and tax revenues. Given this lack of unequivocal evidence and the profound policy implications of this issue, it is necessary to investigate the direction of causality between the two variables using more advanced methods.

The purpose of this paper therefore is to reexamine the causality between revenues and expenditures in a multivariate framework by applying the techniques of cointegration and Hsiao's version of the Granger causality method to U.S. postwar data for the period 1946-96, as explained below. Section II presents the methodology and model. The third and fourth sections report the empirical results and conclusions, respectively.

II. METHODOLOGY AND MODELS

According to Granger (1969 and 1980), if a series x_t contains information in past terms that helps in the prediction of y_t and if this information is contained in no other series used in the prediction, then x_t is said to cause y_t. Thus, a variable x_t is said to Granger-cause y_t if the prediction of the current value of y_t is improved by using past values of x_t.

As noted, in contrast to earlier U.S. studies, a multivariate, rather than a bivariate model is used in this study. Bivariate casualty tests have fallen out of favor in macroeconomics because it has become quite clear that the results of the causality tests are extremely sensitive to omitted variables. Darrat and Suliman (1994) have argued that in the bivariate model, if x_t is found not to cause y_t, it does not necessarily imply that such an inference holds in the context of a larger economic model which includes other relevant variables. Lutkepohl (1982) has also noted that a low dimensional subprocess contains little information about the structure of a higher dimensional system and that Granger casualty is severely affected by bias caused by the omission of relevant variables. Granger (1969), Sims (1980), and Serletis (1988) have also argued that Granger casualty is severely affected when using the restrictive bivariate model.

Following earlier studies, government expenditures (G) are modeled as a function of revenues (T). However, standard macroeconomic theory suggests the potential importance of the rate of growth of GDP, because changes in the GDP growth rate also change government expenditures and tax revenues. Therefore, GDP is added to the expenditure/revenue equation. Note all variables are expressed in logs.

$$\text{Log } G = f(\log T, \text{Log } GDP). \tag{1}$$

The model can then be transformed into one causality equation and rewritten by specifying a causality:

$$(1-L)\begin{bmatrix} \log y_t \\ \log x_t \end{bmatrix} = \begin{bmatrix} \alpha_1 & \delta_1 \\ \alpha_2 & \delta_2 \end{bmatrix}\begin{bmatrix} 1 \\ e_{t-1} \end{bmatrix}$$

$$+ \sum_{i=1}^{p} (1-L)\begin{bmatrix} \beta_{11i} & \beta_{12i} & \beta_{13i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} \end{bmatrix}\begin{bmatrix} \log y_{t-i} \\ \log x_{t-i} \\ \log z_{t-i} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix}, \tag{2}$$

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where: y = government expenditures (G) in current dollars,
x = tax revenues (T) in current dollars,
z = GDP in current dollars,
L = the lag operator and (1-L)=d is the difference operator such that $(1-L)y_t = y_t - y_{t-1}$ represents the first difference.
v_{it} = the white noise disturbance terms,
e_{t-1} = the error-correction term (ECM) which is the one period lag of e_t which in turn is the stationary residuals from the multi-cointegration equation:

$$y_t = \alpha_0 + \alpha_1 x_t + \alpha_2 z_t + e_t. \quad (3)$$

We follow Miller's (1991) approach to error-correction modeling and choose the conditioning (left-hand-side) variable which maximizes the adjusted R-squared.

This study uses annual data that cover the period 1946-96 for the U.S. The data for GDP, government expenditures and tax revenues are compiled from the Economic Report of the President (various years). Current dollars are used because budgetary decisions for the most part are made in nominal terms and nominal variables determine debt accumulation.

III. UNIT ROOT AND COINTEGRATION TESTS

Hsiao's (1981) version of the Granger causality test requires that all variables be stationary[1]. Hence, our first step after presenting the models is to test for the properties of unit roots/stationarity of all three variables in the model. The Phillips-Perron (Phillips and Perron, 1988) tests (PP test) therefore are performed and the results, shown in table 1, indicate the tax, expenditure and GDP series are each I(1). However, the PP tests reveal that all three I(1) series become stationary or I(0) after first differencing.

Table 1 Results of the Phillips-Perron (PP) Unit Root Tests Before and After Differencing the Data

Variable	The PP value	The Critical Value
A. The Levels		
Expenditures (G)	-0.7132	-3.13
Tax Revenues (T)	-0.9653	-3.13
GDP	-2.9234	-3.13
B. First Differences		
Expenditures (dG)	-7.1167*	-3.13
Tax Revenues (dT)	-6.0537*	-3.13
GDP (dGDP)	-5.5760*	-3.13

* denote non-stationarity (see Fuller, 1976).

Table 2 Johansen's Cointegration Test Statistics

	Maximal Eigenvalue Test			Trace Test		
Null H	Alternative H	Eigen-value	C.V. 99%	Alternative H	LR Ratio	C.V. 99%
r=0	r=1	30.31**	26.41	r≥1	56.26**	40.20
r≤1	r=2	21.63**	19.83	r≥2	25.95**	24.99
r≤2	r=3	4.32	12.74	r≥3	4.32	12.74

Notes: C. V.=critical value; H=hypotheses and PP=Phillips-Perron.
**denotes two cointegration ranks.

Subsequently, the cointegration test is performed to check whether the simple Granger causality test is appropriate. Note that cointegration is the statistical approach which tests for the existence of long-run equilibrium relationships among non-stationary variables which are integrated to the same order. In testing for cointegration, we employ the Johansen test (Johansen and Juselius, 1990) because this test is a more powerful cointegration test, particularly when a multivariate model is used. Moreover, Johansen's test is robust to various departures from normality in that it allows any of the three variables in the model to be used as the dependent variable while maintaining the same cointegration results. The results of the Johansen test, as reported in table 2, reveal the existence of more than one cointegrating vector, indicating that the three variable are cointegrated[2]. The existence of more than one cointegrating vector may indicate that the system under examination is stationary in more than one direction and hence more stable (Dickey et al., 1994; Lee, 1997; Vamvoukas, 1997).

It is worth noting that the differencing process tends to filter out low-frequency lagged regressors which may contain valuable information concerning the long-run equilibrium properties of the data. Incorporating the error-correction terms into the models reintroduces the lost information (Granger, 1988; Miller, 1991).

According to Engle and Granger (1987), cointegrated variables must have an ECM representation. Furthermore, including the error-correction term, e_{t-1}, in the equations (3) throughout (5) below, introduces an additional channel through which Granger causality can be detected. Take equation (3) as an example. Granger (1988) noted that in the error-correction model there are two possible sources of causation of y_t by x_{t-i}, either through the e_{t-1} term, if $\delta_i \neq 0$, or through β_j. Thus, the error-correction terms in the two equations can be used to gauge the long-run causal relationship between taxes and spending.

IV. Hsiao's Version of the Granger Causality Tests

While Granger's method discussed above is widely used in applied research, its application is restricted to models with identical lag lengths. In traditional vector autoregression models, a fixed lag length is imposed on all variables and across all observation periods. However, Lee (1997) argued, this practice can result in potential model misspecification. More specifically, underparameterization due to a too short lag length results in estimation bias, while overparameterization due to a too long lag length causes a loss of degrees of freedom and thus estimation efficiency. The final prediction error (FPE) criterion that we use in this paper is appealing because, as Hsiao (1981) points out, it balances the risk of selecting a higher lag against the risk of a lower lag. When an additional lag is included, the first term in

FPE is increased, but simultaneously the second term is decreased. When their product (FPE) reaches a minimum, the two opposing forces are balanced.

Hsiao's method works well for a bivariate model. For a multivariate equation model, however, it does not ensure that the results of the autoregression (AR) equation will remain the same when the order in which regressors are introduced is changed. In this study, the specific gravity criterion (SGC) proposed by Caines, Keng, and Sethi (1981) is used to determine the sequence in which the regressors are added at each stage. For instance, if a process y_t has n multiple causal variables, x_1, x_2, x_3, x_4....x_n, we first rank them according to the decreasing order of their specific gravities or the increasing order of their smallest FPE value. Accordingly, the variable with the minimum FPE among the bivariate equations is first added while each remaining variables is added one at a time.

Notice that equation (1) can be broken down into two equations: an expenditure equation and a revenue equation. The expenditure equation in turn can be broken down into three causality equations: a univariate equation, a bivariate equation and a trivariate equation as follows:

$$(1-L)y_t = \alpha_0 + \delta_1 e_{t-1} + \sum_{i=1}^{M} \alpha_i \, (1-L)y_{t-i} + v_{1t}, \tag{4}$$

$$(1-L)y_t = \alpha_0 + \delta_1 e_{t-1} + \sum_{i=1}^{M} \alpha_i \, (1-L)y_{t-i} + \sum_{j=1}^{N} \beta_j \, (1-L)x_{t-j} + v_{2t}, \tag{5}$$

$$(1-L)y_t = \alpha_0 + \delta_1 e_{t-1} + \sum_{i=1}^{M} \alpha_i (1-L)y_{t-i} + \sum_{j=1}^{N} \beta_j (1-L)x_{t-j} + \sum_{k=1}^{P} \varphi_k (1-L)z_{t-k} + v_{3t}. \tag{6}$$

Finally, after transforming the original data, we proceed to perform the causality tests employing Hsiao's version of the Granger causality method. For details of Hsiao's procedure, see the appendix.

For the purpose of comparison, we first perform tests using a bivariate model. The results, as shown in table 3, indicate that for the expenditure equation, taxes do not Granger-cause expenditures since 0.2440035E-02 > 0.236116E-02. By the same token, for the revenue equation, we conclude that expenditures Granger-cause revenues since 0.3302899E-02 < 0.3350230E-02. Thus, the bivariate model results show that causality runs unidirectionally from expenditures to revenues in the short run.

Subsequently, the trivariate causality tests are performed and the results are strikingly different. As shown in Table 3, for the expenditure equation, GDP is added to the equation first and since 0.17332166E-02 < 0.2341116E-02, we conclude that GDP Granger-causes expenditures. Next, revenues are entered into the equation and since 0.19895555E-02 > 0.17332166E-02, we conclude that revenues do not Granger-cause expenditures. In sum, GDP is found to Granger-cause expenditures, whereas revenues are found to Granger-cause expenditures. Conversely, for the revenue equation, as indicated in the same table, GDP is entered into the equation first and we conclude that GDP Granger-causes revenues since 0.1910552E-02 < 0.3350230E-02. Finally, expenditures are added to the equation and we conclude that expenditures do not Granger-cause revenues since 0.1977002E-02 > 0.1910552E-02. In sum, GDP is the only variable that is found to cause tax revenues in the United States. Interestingly, the results from the bivariate and trivariate models are completely different. While the bivariate tests indicate that expenditures Granger-cause revenues without feedback, the trivariate tests reveal that neither revenues nor expenditures cause each other. It is GDP that is found to cause both government expenditures and tax revenues. This strongly demonstrates that specification does matter a great deal for the causality test. In addition to the direction of causality, the sign of the causal relation between taxes and expenditures is also of great importance. The t- and Wald-tests therefore are performed and the results (table 4) fully corroborate the causality tests[3].

Table 3 Results of the Hsiao's Version Causality Tests

Controlled Variable	First Manipulated Variable	Second Manipulated Variable	FPE	Causality Inferences
The Bivariate Models				
(a) Expenditure Equation:				
G(i=5)			0.2341116E-02	
G(i=5)	T(j=1)		0.2440035E-02	T≠>G
(b) Revenue Equation:				
T(i=6)			0.3350230E-02	
T(i=6)	G(j=1)		0.3302899E-02	G⇒T
The Trivariate Models				
G(i=5)			0.2341116E-02	
G(i=5)	GDP(j=4)		0.1733216E-02	GDP⇒G
G(i=5)	GDP(j=4)	T(m=1)	0.1989555E-02	T≠>G
T(i=6)			0.3350230E-02	
T(i=6)	GDP(j=2)		0.1910552E-02	GDP⇒T
T(i=6)	GDP(j=2)	G(m=1)	0.1917002E-02	G≠>T

Notes: G=expenditures and T=tax revenues. The figures in parentheses behind the variables are the optimal lag length.

Table 4 The t- and Wald Chi-Squared Statistics of the Trivariate Models[2]

(a) The Expenditure Equation:

$$(1-L)G_t = \underset{\substack{(0.00452)\\0.95}}{\alpha_0 + \delta_1 e_t} - \underset{\substack{(5.27847)\\0.00^*}}{\sum_{i=1}^{5} \alpha_i (1-L)G_{t-i}} + \underset{\substack{(7.14087)\\0.00^*}}{\sum_{j=1}^{4} \beta_j (1-L)GDP_{t-j}}$$

$$- \underset{\substack{(0.10394)\\0.75}}{\sum_{m=1}^{1} \varphi_m (1-L)T_{t-m}} + v_{1t}.$$

(b) The Revenue Equation:

$$(1-L)T_t = \underset{\substack{(2.10845)\\0.15}}{\alpha_0 + \delta_2 e_t} - \underset{\substack{(2.10914)\\0.08^{**}}}{\sum_{i=1}^{6} \alpha_i (1-L)T_{t-l}} + \underset{\substack{(13.83980)\\0.00^*}}{\sum_{j=1}^{2} \beta_j (1-L)GDP_{t-j}}$$

$$+ \underset{\substack{(0.62615)\\0.54}}{\sum_{m=1}^{1} \varphi_m (1-L)G_{t-m}} + v_{2t}.$$

Note: The statistics of the joint significance of the coefficients are reported in parentheses and the number beneath each corresponding parenthesis represents the p-value (the significant level).
* significant at the 1% level.
** significant at the 10% level.

The finding that expenditures do not Granger-cause taxes runs counter to Barro's views that higher government spending drives up taxes (Barro, 1974). This result is also at odds with Friedman's belief (Friedman, 1978) that increasing taxes only results in more spending. Our results indicate that neither revenues nor expenditures respond to a short run budgetary disequilibrium. Taxes and spending each adjust to a disequilibrium independently. Changes in expenditure levels respond to economic growth, rather than changes in taxes. Government expenditures often increase due to a rising demand for government services that are caused by higher income, population growth, and other domestic and international events rather than increased revenues. Likewise, tax revenue increases are caused by increased GDP rather than government expenditures. In other words, in the United States, where spending goes, taxes do not necessarily follow.

Caution should be exercised in interpreting the above causality results. Buchanan and Wagner (1977) have pointed out that sources of financing for public expenditures other than taxation are available and thus may distort the tax-expenditure causal relationship, particularly when politicians have a tendency to increase debt financing rather than tax financing during an election year. In fact, government spending is often financed by some combination of direct taxation and borrowing (including monetizing the debt). In financing the budget deficit, politicians, through borrowing, deliberately lower the perceived tax price of public goods and services to gain public support and secure re-election (Hasan and Lincoln, 1997). Consequently, people increase their demand for such goods and services and thus the government grows larger.

Based on our observation of the federal budgetary process over the past two decades in the U.S., government spending has grown through deficit financing since the late 1970s and especially after the early 1980s. An inspection of the data reveals that during the Reagan years (1981-88), government spending grew from $698.4 billion to $1,035.6 while tax revenue only rose from $622.3 billion to $925.7 billion. Consequently, the budget deficit climbed from $76.1 billion to $140.5 billion. This increase was totally financed by public borrowing. Thus, increased government expenditures more often are financed by an increase in the public debt rather than by an increase in tax revenues. This seems to reflect Buchanan and Wagner's (1977) argument that politicians most often chose debt-financing over tax-financing because the latter is less popular politically and not likely to win Congressional approval. Increasing taxes may not only be economically unsound, but also politically undesirable especially if elected officials wish to get reelected. Obviously, continuous economic growth since April 1991 and the end of the cold war have lead to the current Federal budget surplus.

Moreover, while our results from the bivariate model are consistent with the bivariate studies by von Furstenberg et al (1985) and Anderson et al (1985) which did not use error-correction models but concluded that spending Granger-causes taxes in the short run, our trivariate study do not support these studies. However, our results from the trivariate study do not agree with the bivariate studies of Bohn (1991), Jones and Joulfaian (1991), and Miller and Russek (1990), Owoye (1995) and Hasan and Lincoln (1997) who found bidirectional causality between the two variables in the short run. This strongly indicates that omitting any relevant variable may generate biased or spurious causality results.

V. CONCLUSIONS

The paper seeks to extend and advance earlier empirical research on the relation between taxes and spending. First, by testing cointegration, we ascertain that error-correction modeling must be incorporated in analyzing the relationship between government expenditures and tax revenues. Second, by employing Hsiao's version of the Granger's causality method, we use the FPE criterion to estimate the optimum lag length, which improves the statistical estimation between taxes and spending. Third, by adding the third variable, GDP, we avoid biases caused by omitting relevant variables. Finally, we conduct the t- and Wald-tests to estimate the sign of causality between expenditures, revenues and GDP.

Contrary to earlier bivariate studies, this study finds no evidence of causality between expenditures and revenues. Instead, we find that GDP causes both revenues and expenditures. This strongly demonstrates that the omission of any relevant variables may generate spurious causality results. This result is due to the institutional separation of the allocation (expenditure) and tax collection functions of government.

The policy implication of this is that changes in taxes and expenditures that are intended to reduce the budget deficit do not necessarily offer a permanent solution to underlying fiscal problems in the U.S. While our tests do not provide the final answer to the deficit issue, they imply that policy makers will find it difficult to balance the budget or reduce budget deficits because taxes in the US do not affect and are not affected by expenditures. However, it implies that maintaining steady, continual, non-inflationary economic growth coupled with selective spending reduction and tax increase may be a more effective way to reduce budget deficits or even increase budget surpluses in the U.S. What we have observed in the last two years in the U.S. budget that has turned from deficits to surpluses is a testimony to this conclusion.

ENDNOTES

1. A process is stationary if the mean, the variance, and the covariances of the error term do not change over time. If economic data are stationary, they can be thought of as "nicely behaved." For instance, in table 1, since the PP value of expenditures, 0.7132 is less than 3.13 it is not stationary. Because most economic data are trending, that is, the mean changes over time, they clearly cannot be stationary. One difficulty that arises when employing regression with clearly non-stationary series is the spurious problem, that is, the conventional t-test will tend to indicate a relationship between the variables when none is present. This is particularly likely when the adjusted coefficient of determination (R^2) exceeds the D-W statistic. High R^2s may indicate correlated trends and not true economic relationships while low D-W statistics may reflect nonstationary residuals. In such situations, the usual ordinary least squares significance tests can be quite misleading. Therefore, it is important to test for stationarity before proceeding with the causality estimation. See D. N. Gujarati (1996) and Granger and Newbold (l974).
2. As shown in table 2, the trace test statistic for at most one cointegrating vector (null H_0: r=0; alternative H: r≥1) is 56.26 and the 99% critical value given in Johansen table is 40.20 so that the null hypothesis is rejected and thus there is evidence for cointegrating relations in the data.
3. Neither F-test nor Wald-test can show the direction of causality. The direction of causality is estimated by using the Granger causality method. Nevertheless, we find that it is necessary to gauge the nature of causal relationship because if x_t is found to cause y_t, it could mean that (a) x_t positively causes y_t or (b) x_t negatively causes y_t. To obtain the complete information therefore, we performed the t- and Wald-tests to estimate the joint significance levels of causality between the two variables as well as the nature (negative or positive) of this relationship.

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APPENDIX

Hsiao's (1981) method essentially follows a two-step procedure to simultaneously determine the optimum lag lengths (using Akaike's (1969) FPE criterion and the directions of causality. The procedure used to implement Hsiao's version of the Granger-causality tests is given as follows:

(i) Using Equation (4) for illustration, in step one we treat the dependent variable, y_t, as a one-dimensional autoregressive process and compute its Final Prediction Error (FPE) using the equation with the maximum order of lags varying from 1 to M. The corresponding FPE is calculated using the following equation:

$$FPE(m) = \frac{(T + M + 1)}{(T - M - 1)} \bullet \frac{SSE}{T}, \tag{7}$$

where T = total number of observations,
M = the order of lags varying from 1 to M, and
SSE = the sum the squared errors.

(ii) In step 2, we choose the order which yields the smallest FPE, m*. Focusing on Equation (5), we then treat y_t as a controlled variable, with the order of lags set at m*, and x_t as a manipulated variable. Using Equation (5) we again compute the FPE of y_t by varying the order of lags of x_t from 1 to N and determine the order which yields the smallest FPE, n*. The corresponding two-dimensional FPE is

$$FPE(m^*,n) = \frac{(T + m^* + n + 1)}{(T - m^* - n - 1)} \bullet \frac{SSE(m^*,n)}{T}, \tag{8}$$

where n = the order of lags on x(t) varying from 1 to N, and
m* = the optimum number of lags computed from (7).

If FPE(m*,n*) is less than FPE(m*), we then conclude that tax revenues (x_t) Granger-cause expenditures (y_t). Subsequently, by using the same procedure, FPE(m*,n*) and FPE(m*, n*, p*) can be obtained and compared with each other. By repeating the same procedure for the tax revenue equations, causality from expenditures and income to revenues may also be estimated.