

THE CAUSAL RELATIONSHIP BETWEEN TAXES AND EXPENDITURES IN PORTUGAL: COINTEGRATION AND ERROR-CORRECTION MODELS

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1 — Introduction

The reduction of fiscal deficit is one of the purposes of Portuguese government in order to achieve the convergence criterion on deficits for participation of Portugal in the European Monetary Union (EMU). However, the reduction of the deficit may be achieved either by increasing taxes or decreasing expenditures or both. But if taxes cause expenditures, an increase in taxes implies an increase in expenditures and the deficit may incidentally increase. If expenditures cause taxes, a cut in expenditures induces a cut in taxes and again the deficit may not reduce. Hence, the existence and direction of causality between expenditures and revenues is an important issue.

Recently, a number of studies have investigated the causal relationship between government expenditures and tax revenues for several countries. For example, the studies of Anderson et al. (1986), Ram (1988a), Joulfaian and Mookerjee (1990a) and Manage and Marlow (1986) for the United States, and for other countries, Ram (1988b) for a group of 22 countries including developed and developing countries, Joulfaian and Mookerjee (1990b) for 17 OECD countries, Baffes and Shah (1994) for three Latin American countries (Argentina, Brazil and Mexico), and Owey (1995) for the most developed countries (G7 group).

These papers use different methodologies and different types of data. With respect to the methodology, most studies use the conventional Granger-Sims causality tests but others use most recent developments of the econometric techniques, namely, cointegration and error-correction models.

In the present paper we apply the cointegration and error-correction methodology to examine the causal relationship between government expenditures and government tax revenues in Portugal over the period 1958-1991.

The rest of the paper is organized as follows. Section 2 presents a review of the relevant literature, section 3 describes the econometric methodology and section 4 presents the data and discusses the empirical results. Finally, section 5 summarizes and concludes the paper.

2 — Literature review

Three main hypotheses or theories on the direction of the causality between government expenditures and government revenues may be

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postulated: the first states there is a bidirectional causal relationship; according to the second, revenues (taxes) may lead government spending; and the third advocates that spending may lead taxes.

According to the first theory, expenditures and taxes are decided by the governments jointly. This is the case often referred in textbooks on Public Economics [see, for example, Musgrave (1966) and Meltzer and Richard (1981)]. The second hypothesis, expenditures adjust to taxes is consistent with the literature on state and local finances and finds also support among supply-side economists. These authors argue that increases in taxes only result in increased expenditures and not in deficit reduction [see Roberts (1984)]. The third situation occurs when taxes adjust to expenditures and was explored in Peacock and Wiseman (1979). These authors found that temporary changes in government spending lead to permanent changes in taxes.

There is yet a fourth possibility: absence of causal relationship between expenditures and taxes. According to this hypothesis, expenditures and taxes are decided in a independent causal way.

The fundamental question is: which of these hypotheses is supported for each country or for each group of countries? The analysis in the literature is conducted at state or local level as well as at the federal level. The most studies on causality between expenditures and taxes are concerned with the U. S. However, there are some studies for other countries, including developed and least developed countries. The findings of these studies are mixed. For Portugal, as far as we know, Joulfaian and Mookerjee (1990b) is the only work where the issue of causality between government expenditures and taxes is studied. The results of this study concerning Portugal support the tax-and-spend hypothesis:

Overall, the results suggest that the tax-and-spend hypothesis seems more relevant in the U. S., Canada, and Portugal, and the spend-and-tax hypothesis in countries such as Japan, the United Kingdom, France and Greece, Ireland, and the Netherlands. [Joulfaian and Mookerjee (1990b), page 112.]

The evidence on the relevance of the above four hypotheses is mixed in current literature. For example, for the United States, Manage and Marlow (1986) have found some evidence of a unidirectional relationship from revenues to expenditures while von Furstenberg et al. (1985, 1986) and Anderson et al. (1986) found support for the causality in the opposite direction, that is, the spend-and-tax hypothesis. According to the results of the latter authors, spending increases lead to tax increases and not vice-versa.

Ram (1988a) has extended the studies for the U. S. made by Anderson et al. (1986) and by Manage and Marlow (1986) in the following directions. He has conducted causality tests not only for federal receipts and expenditures but also for total state and local government receipts and expenditures. He has used annual data covering the period 1929-1983 and quarterly data over the period 1947-1983 for both federal and state-local government sectors and considered nominal and real data. For real data, Ram (1988a) has considered three different measures of real data which are based on three different deflators: the

Consumer Price Index (CPI), the implicit GNP deflator, and the implicit deflator for the federal or the state-local government sector. His major conclusion is the following:

There is considerable variation in the results for different cases. In general, however, it seems that causality runs mainly from revenue to expenditure in the federal data, but predominantly from expenditure to revenue in data for the state and local government sector. [Ram (1988a), page 763.]

Ram (1988b) investigates the causal relationship between government expenditures and revenues for a group of 22 countries including developed countries (DC) and least developed countries (LDC). His results are mixed:

The most significant aspect is that there is much cross-country variation in the causal patterns and it is hazardous to draw general conclusions. Along with the lack of a significant causal flow in most cases, one can find practically any causal pattern by selecting a suitable subset of countries. [Ram (1988b), page 263.]

With respect to the state of development of the countries he concludes «there is no discernible difference between the results for the DCs and the LDCs» and with respect to nominal or real data, there is almost as many cases of causality from revenue to expenditures as of causal flow in the opposite direction for nominal data and for real data, «[...] when one does observe a significant causal order, causality seems to run more frequently from revenue to expenditure» [Ram (1988b), page 263].

Miller and Russek (1990) apply cointegration and error-correction models to examine the causal relationship between tax revenues and expenditures for the U. S. They show how sources of causality can be neglected in standard Granger causality tests. They use quarterly data and their results suggest bidirectional causality between government taxes and expenditures, both for the federal, and state and local levels.

Baffes and Shah (1994), besides the examination of the causality relationship between expenditures and taxes, test also the stationarity hypothesis of fiscal deficits for Argentina, Brazil, and Mexico. They use cointegration and error-correction models for the causality tests, the fiscal deficit being the error-correction term for the countries where the deficits were stationary. Their findings suggest that deficits were stationary in Argentina and Mexico but not in Brazil. Regarding the direction of causality, they found bidirectional causality for Argentina and Mexico and unidirectional causality running from revenues to expenditures for Brazil.

Owoye (1995) applies also cointegration and error-correction models to examine the causal relationship between tax revenues and expenditures for the G7 countries. His results show that bidirectional causality exists between government taxes and government expenditures in all countries except in Japan and Italy. For Japan and Italy he found that the direction of the causality runs from government taxes to expenditures.

3 — Econometric methodology

In this paper, besides the standard Granger causality test, we use cointegration and error-correction modelling to investigate the causal linkage between government expenditures and tax revenues. Since cointegration is applied to nonstationary time series and the standard Granger causality tests and the error-correction modelling require stationary series, the econometric methodology follows in three steps. In the first, the properties of the time series are studied. Unit roots tests are performed for determination of the order of integration of the series.

In the second step, the series are tested for cointegration, and in the third step, an error-correction model is estimated and used for testing the existence of causality between government expenditures and government tax revenues.

3.1 — Unit root tests

The unit root tests we apply are the Dickey-Fuller (DF), the Augmented Dickey-Fuller (ADF) tests [Dickey and Fuller (1979,1981)] and the test suggested by Phillips (1987) and Phillips and Perron (1988). The latter is more robust than the ADF test in the cases where there is autocorrelation or heteroscedasticity.

These tests are performed to determine the series order of integration. The order of integration of a series is the number of times a series need to be differenced to achieve stationarity. The tests are implemented in the following way.

Let denote a particular series by y_t ($t = 1, 2, \dots, T$). The Dickey-Fuller (DF) test is based on the estimation of one of the following two equations:

$$\Delta y_t = \mu_1 + \alpha_1 y_{t-1} + \varepsilon_{1t} \quad (1)$$

$$\Delta y_t = \mu_2 + \beta t + \alpha_2 y_{t-1} + \varepsilon_{2t} \quad (2)$$

where ε_{1t} and ε_{2t} are the assumed uncorrelated error terms of the equations. In the second equation a time trend is considered while in the first equation it is not. The null hypothesis H_0 states that the series has a unit root (i. e., the series is nonstationary). Formally, the null hypothesis H_0 is $\alpha_1 = 0$ or $\alpha_2 = 0$ according to the equation considered. For testing the null hypothesis we compute the t -statistic in the usual way but the distribution of this statistic is nonstandard. Critical values were supplied by Dickey and Fuller (1979,1981). If H_0 is rejected, the series y_t is stationary and if H_0 is not rejected the series is nonstationary. For those series which are nonstationary differencing is needed.

If the error terms are correlated, lagged values of the dependent variable are added until the errors are noncorrelated and we have then the Augmented Dickey-Fuller (ADF) test.

An alternative test is the test suggested by Phillips and Perron (1988) whose statistic test (Z statistic) is a transformation of the Dickey-Fuller statistic. Hereafter this test will be referred as the PP test.

The tests are performed on the basis of the estimation of one of the following two auto-regressive equations:

$$\Delta y_t = \mu_1 + \alpha_1 y_{t-1} + \sum_{i=1}^k \delta_i \Delta y_{t-i} + \varepsilon_{1t} \quad (3)$$

$$\Delta y_t = \mu_2 + \beta t + \alpha_2 y_{t-1} + \sum_{i=1}^k \gamma_i \Delta y_{t-i} + \varepsilon_{2t} \quad (4)$$

In the practice, we follow a sequence of tests [see Dickey and Fuller (1981), page 1070, table x]:

- 1) $H_0 : \alpha_2 = 0$;
- 2) $H_0 : \alpha_2 = \beta = \mu_2 = 0$;
- 3) $H_0 : \alpha_2 = \beta = 0$;
- 4) $H_0 : \alpha_1 = 0$;
- 5) $H_0 : \alpha_1 = \mu_1 = 0$.

These tests are performed until all test statistics are significant. If we could not reject the null hypothesis, the series is nonstationary in levels. DF, ADF and the PP test of Phillips and Perron are then performed on the series of first differences. If the null of a unit root is rejected, the series in differences is stationary and thus the series in levels is $I(1)$. If the null hypothesis is not rejected, the series of the first differences is nonstationary and one performs DF, ADF and the PP tests on the second differences and so on. The order of integration of a time series is the number of times a series must be differenced for achieving stationarity.

3.2 — Cointegration tests

With respect to cointegration tests, two types of cointegration tests are applied: the Engle-Granger test and the Johansen test.

The cointegration tests require that both variables under consideration are of the same order of integration. Two series integrated of order one are cointegrated if both have a common trend, that is, if there is a linear combination of them which is stationary. In the case of cointegration, the two series can not drift apart one from the other. The second step is thus to test whether the two series are cointegrated.

Let us first describe the Engle-Granger cointegration test and then the Johansen's maximum likelihood test of cointegration.

Let denote the two time series by y_t and x_t (in the application these series are the growth rates of government expenditures and tax revenues, respectively). The Engle-Granger cointegration test is based on the OLS residuals of the following cointegration equations:

$$y_t = \alpha + \beta x_t + u_t \quad (5)$$

$$x_t = \alpha' + \beta' y_t + v_t \quad (6)$$

where u_t and v_t stand for the error terms of the equation regressions.

The null hypothesis of the Engle-Granger cointegration test is that the two variables $I(1)$ are not cointegrated. If the variables are not cointegrated the residuals u_t and v_t are not stationary. Therefore, the cointegration test is a unit root test of the series of residuals.

The Johansen's likelihood test is applied in the following way. Suppose that the data-generating process for a vector z_t of $N I(1)$ variables may be written as an m th-order vector autoregression (VAR):

$$z_t = \Pi_1 z_{t-1} + \Pi_2 z_{t-2} + \dots + \Pi_m z_{t-m} + \alpha + \eta_t$$

where η_t is independent mean 0 with a constant variance.

This equation may be rewritten as:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \Gamma_2 \Delta z_{t-2} + \dots + \Gamma_{m-1} \Delta z_{t-m+1} + \Gamma_m \theta z_{t-m} + \alpha + \eta_t$$

where $\Gamma_j = -I + \Pi_1 + \dots + \Pi_j$ ($j = 1, 2, \dots, m$) and $\Gamma_m = -I - \Pi_1 - \dots - \Pi_m$.

The test is a test on the rank of the matrix Γ_m . The rank of this matrix determines the number of distinct cointegrating vectors which exist between the variables in z . Thus, if Γ_m has rank of 0, then the null hypothesis of no cointegration cannot be rejected.

Defining two $N \times r$ matrices α and β such that:

$$\Gamma_m = \alpha \beta'$$

the rows of β' form r distinct cointegrating vectors such that, if β_i is the i^{th} row of β' :

$$\beta_i' z_t \sim I(0)$$

Johansen (1988) demonstrates that the likelihood ratio (LR) test statistic for the hypothesis that there are at most r distinct cointegrating vectors is:

$$LR = -T \sum_{i=r+1}^N \ln(1 - \hat{\lambda}_i)$$

where $\hat{\lambda}_{r+1}, \dots, \hat{\lambda}_N$ are the $N - r$ smallest square canonical correlations between the z_{t-k} and Δz_t series, corrected for the effect of the lagged differences of the z process [for details of how to extract the $\hat{\lambda}_i$ see Johansen (1988, 1991)]. Johansen (1988) shows that LR will have a non-standard distribution under the null hypothesis. He does, however, provide approximate critical values for this statistic, generated by Monte Carlo methods.

Cointegration is very important with respect to causal relationships. In fact, if two variables are cointegrated we know, from the Engle and Granger's representation theorem, that they may be modelled by an error-correction model and that there is at least a unidirectional causal relationship between the two variables.

3.3 — Causality tests

In the literature on causality there are several tests for testing the existence of a causal relationship between two variables.

One of these tests is Granger's (1969) direct test based on his definition of causality. According to this definition, y causes x if the past values of y improve the prediction of x . This is the standard Granger causality test and requires stationary variables. The test is performed in the following way.

Assuming that the variables in levels are integrated of order one, $I(1)$, the series of the first differences are $I(0)$. Therefore, the test is based on the two following equation regressions:

$$\Delta y_t = \alpha_1 + \sum_{i=1}^m \beta_{1i} \Delta y_{t-i} + \sum_{j=1}^n \gamma_{1j} \Delta x_{t-j} + \varepsilon_t \quad (7)$$

$$\Delta x_t = \alpha_2 + \sum_{j=1}^n \gamma_{2j} \Delta x_{t-j} + \sum_{i=1}^m \beta_{2i} \Delta y_{t-i} + \eta_t \quad (8)$$

The small sample properties of this test and the test proposed by Sims (1972) and a modified Sims test suggested by Geweke et al. (1983) were studied by Guilkey and Salemi (1982). These authors concluded that «the Granger test performs slightly but significantly better than the other tests» (page 673). Moreover, «since the Granger test is computationally the least expensive of the three and results in the fewest degrees of freedom lost from formation of lags and leads», the authors «recommend it confidently to the practitioner» [Guilkey and Salemi (1982), page 679]. According to the authors, for sample size less than 200 the shorter versions of all three tests are superior to the longer versions. For these reasons, the causality tests we use in this paper are of Granger type.

However, a more comprehensive test of causality was provided by Granger (1983, 1986) and Engle and Granger (1987). This new causality test applies cointegration and error-correction methodology and allows for a causal linkage between two variables stemming from a common trend or equilibrium relationship. If two variables have a common trend, that is, are cointegrated, the lagged level of one of the variables may help to explain the current change in another variable, even if past changes of the former do not. This causality may not be detected by the standard Granger causality test [see Miller and Russek (1990)].

For testing causality by applying the error-correction methodology, we add the error-correction term (ECT) to the regression equations 7 and 8. This ECT is the estimated OLS residuals of the cointegration equations (eq. 5 and eq. 6) with one lag:

$$\Delta y_t = \alpha_1 + \sum_{i=1}^m \beta_{1i} \Delta y_{t-i} + \sum_{j=1}^n \gamma_{1j} \Delta x_{t-j} + \delta_1 \hat{u}_{t-1} + \varepsilon_{1t} \quad (9)$$

$$\Delta x_t = \alpha_2 + \sum_{j=1}^n \gamma_{2j} \Delta x_{t-j} + \sum_{i=1}^m \beta_{2i} \Delta y_{t-i} + \delta_2 \hat{v}_{t-1} + \varepsilon_{2t} \quad (10)$$

The null hypothesis « x does not cause y » is $H_0 : \gamma_{1j} = 0; j = 1, 2, \dots, n; \delta_1 = 0$. If this hypothesis is rejected there is a causal relationship running from x to y ; otherwise, there is not a causal relationship in this direction. The null for testing a unidirectional relationship in the opposite direction is $H_0 : \beta_{2i} = 0; i = 1, 2, \dots, m; \delta_2 = 0$. The rejection of this hypothesis implies there is a one way causal link from y to x . If both hypotheses are jointly rejected there is a bidirectional relationship between expenditures and taxes and, finally, if both hypothesis are not rejected, there is no causal relationship between the two variables. If δ_1 or δ_2 or both are significant then the linkage from long run equilibrium relationship is an important one.

A major concern in performing a causality test is the order of lags among the variables. Some authors use an arbitrary number of lags. The numbers 1, 2, 3 and 4 are common numbers used for annual data. But, as pointed out by Thornton and Batten (1985), an arbitrary number of lags may produce misleading results. An alternative is to use some criterion for the selection of model specification. These authors use three different criteria for specifying the lag length: Akaike's (1970) final prediction error (FPE) suggested by Hsiao (1981), Bayesian estimation criterion (BEC) suggested by Geweke and Meese (1981), and a criterion suggested by Pagano and Hartley (1981). Their results «suggest that the arbitrary lag-length specifications fail to ensure that the results are not based on the capricious choice of the lag-structure» [Thornton and Batten (1985), page 176]. They recommend also that «the safest approach is to perform an extensive search of the lag space» but «even when this approach is taken, however, care must be taken in interpreting the results» (page 177).

According to these authors, among the criteria they considered, the Akaike's FPE criterion is the one suggested. «A comparison of several commonly used criteria for lag-length selection suggests that based on standard, classical, hypothesis-testing norm AKAIKE's FPE criterion performed well in selecting the model relative to the others. As a result, it did a reasonably good job of finding an order of the model which gave evidence of Granger causality, when such an order existed» [Thornton and Batten (1985), page 177].

Following Akaike's formulation of the FPE(m, n) estimate, a two step approach to find the lags values of m and n may be used. First, one selects the value of m (n) which minimizes FPE when regressing Δy_t (Δx_t) on its own lags. Given that m (n) value, the lag values of Δx (Δy) are included in the equation to choose the n (m) value which yields the FPE minimum. Finally, based on these values of m and n , we test the null hypothesis that the coefficients of the lags of Δx (Δy) are jointly zero. However, in the application below we have used a different approach. Although the values of m and n need not be equal, for the sake of simplicity in the computations, we have taken $m = n$ and minimized FPE ($m + n$) for $m = n = 1, 2, 3, 4$.

Another alternative was suggested by Hendry (1986). This author proposes a general-to-specific modelling strategy to eliminate lags with insignificant parameter estimates. According to this strategy, only the lags with significant estimated coefficients are considered in the regressions.

4 — Data and empirical results

The data concern current government expenditures and current tax revenues at current prices (nominal data). The data were obtained from Santos et al. (1992) and cover the period 1958-1991.

Some authors argue that nominal data is more appropriate than real data since the decisions on expenditures and revenues are undertaken at a nominal level. Following these authors, we do not deflate expenditures and tax revenues with a price index thus considering the data at current prices. However, the decisions on taxes and spending are sometimes undertaken as a proportion or percentage of GDP and we could «deflate» the data using as deflator the GDP (actual or potential) as Von Furstenberg et al. (1986) or Hoover and Sheffrin (1992) do.

We have only considered current expenditures and revenues and not total expenditures and total tax revenues because capital expenditures and capital receipts have had a very different behavior in the period covered by the analysis. Total expenditures and total tax revenues as a percentage of GDP will be considered in a future paper.

The time series in natural logarithms of levels are depicted in figure 1 and the first differences (growth rates) in figure 2. These pictures show evidence of nonstationarity of both series in levels and in growth rates.

The second differences of the logarithms of expenditures and revenues (changes of growth rates) are presented in figure 3. According to this graph, second differences seem to be stationary. Thus, the two series appear to be integrated of order two, that is, $I(2)$.

FIGURE 1

Current government expenditures and revenues (in logs)

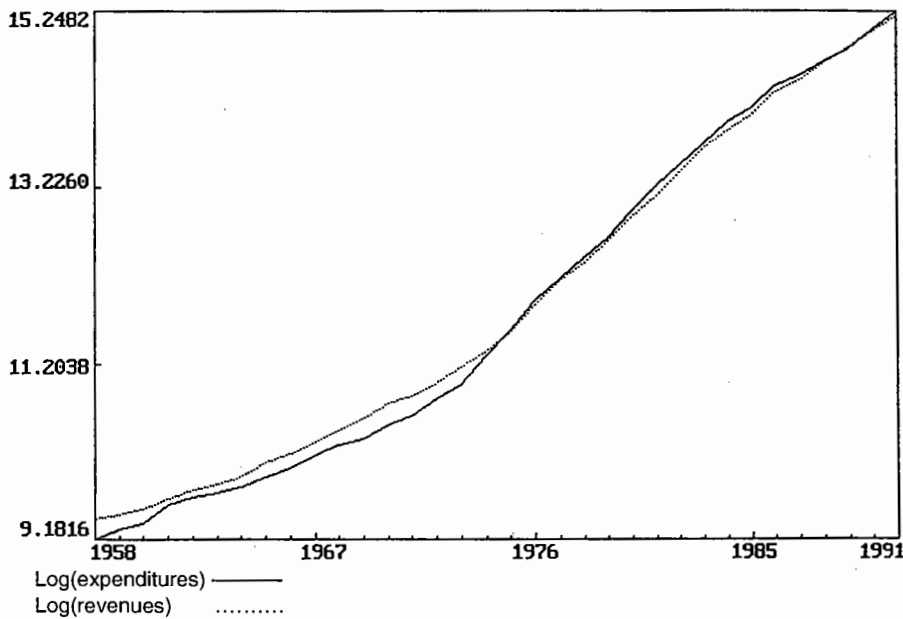


FIGURE 2

Current government expenditures and revenues growth rates

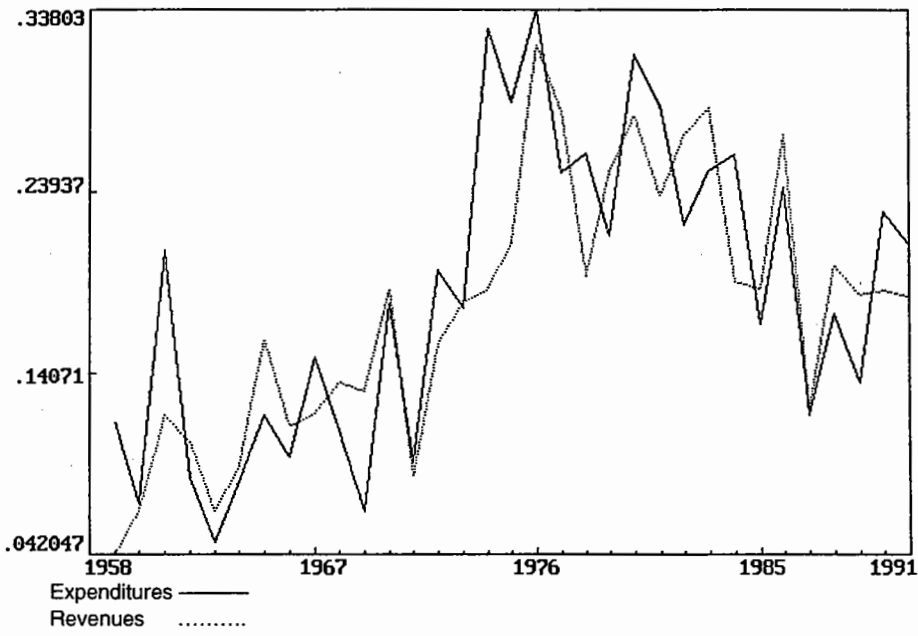
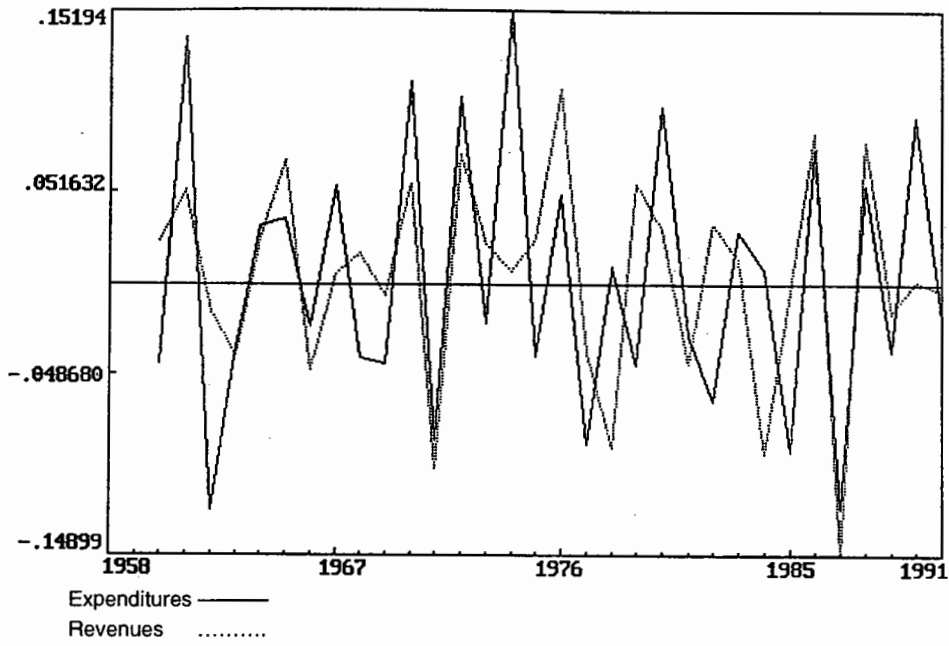


FIGURE 3

Changes of growth rates of government expenditures and revenues



Below, we apply formal tests for the determination of the order of integration of the series. First, we apply the DF, ADF and the PP tests to the series and conclude that tax revenues and expenditures (in logs) are nonstationary series. The application of these tests to the first differences (growth rates) shows that the growth rates of the two time series are also nonstationary. Finally, the null hypothesis of nonstationarity of the second differences is rejected. Therefore, the expenditures and tax revenues series are both integrated of order two, $I(2)$, the first differences (growth rates) being integrated of order one, $I(1)$.

Table 1 reports the results of the DF, ADF and PP tests for the levels of the variables, for the first differences and for the second differences:

TABLE 1
Results of DF, ADF and PP unit root tests

Series	DF	Sign.	ADF(1)	Sign.	k	ADF(k)	Sign.	PP(k)	Sign.
$\ln R$	-2.49	0.33	-2.14	0.52	5	-2.35	0.41	-3.74	0.90
$\Delta \ln R$	-2.86	0.05	-1.92	0.32	4	-1.69	0.44	-10.44	0.12
$\Delta^2 \ln R$	-7.83	0.00	-6.51	0.00	3	-2.57	0.10	-36.93	0.00
$\ln E$	-2.52	0.32	-2.26	0.46	4	-3.35	0.06	-3.68	0.90
$\Delta \ln E$	-2.80	0.06	-1.65	0.45	3	-1.40	0.58	-11.56	0.09
$\Delta^2 \ln E$	-9.95	0.00	-3.48	0.01	2	-3.60	0.01	-48.70	0.00

Notes. — $\ln R$ = tax revenues (in logs); $\ln E$ = expenditures (in logs); k is the optimal number of lags according to the AIC (Akaike Information Criterion) criterion; $\Delta \ln R$ and $\Delta \ln E$ are the growth rates of tax revenues and expenditures, respectively, and $\Delta^2 \ln R$ and $\Delta^2 \ln E$ are the changes of growth rates of tax revenues and expenditures, respectively; the Lagrange Multiplier (LM) statistic for testing first order autocorrelation of the errors corresponding to ADF(1) is not significant for all series.

According to the results of this table, the variables in levels and in growth rates (first differences) are not stationary. However, the second differences are stationary, $I(0)$. Thus, in nominal values, current government expenditures and current government revenues are integrated of order two, $I(2)$.

This result is not very usual in the literature on this subject. In general, the series are either supposed (implicitly) integrated of order one by some authors which do not study the properties of the series but use the first differences of the series (in general in logarithms) or the reported results on stationarity do not reject the hypothesis that the series are integrated of order one.

However, there is at least one exception to this result which is the case of Greece studied by Provopoulos and Zambaras (1991). In fact, according to these authors «[...] both variables were converted into the first difference of logarithms and regressed against time and a constant. Since the coefficient of the time variable proved significant, a second difference specification was deemed necessary to convert both variables to stationary.» [Provopoulos and Zambaras (1991), page 279]. Thus, the (total) government expenditures and taxes in Greece

are also integrated of order two as is the case of (current) expenditures and (current) taxes in Portugal over the period considered.

Like most authors in this area, in what follows we consider the variables in growth rates. Thus, the variables are in natural logarithms converted to growth rates by taking the first differences. Use of growth rates is consistent with fiscal budgetary exercises that are generally undertaken in terms of growth rates and is convenient for the cointegration issue.

In fact, the Engle-Granger cointegration test for two time series requires that both series are integrated of order one, $I(1)$, since the null hypothesis is that the series of residuals has a unit root and the alternative is that the series is stationary, $I(0)$. Thus, in the cointegration equation regressions, we consider the series of the first differences (growth rates) of government expenditures and tax revenues, denoted by y_t and x_t , respectively.

The results of the cointegration tests (DF and ADF) are reported in Table 2. As one may see in this table, the null hypothesis H_0 , the series of residuals have a unit root, is rejected at the 10 % significance level when we use the DF and the ADF(1) tests. The null is not rejected if we consider the optimal lag given by the AIC criterion. However, the LM statistic for testing autocorrelation of the errors of the equation corresponding to the DF or ADF(1) statistics is not significant. Thus, we may consider that the variables (growth rates of expenditures and tax revenues) are cointegrated.

TABLE 2

Cointegration equations and DF and ADF unit root tests for OLS residuals

Dep. var.	Coefficients of			Test statistics							
	Const.	x_t	y_t	DW	DF	Sig.	ADF(1)	Sig.	k	ADF(k)	Sig.
y_t.....	.02	.94	-	1.80	-4.35	.00	-3.19	.07	2	-2.75	.18
x_t.....	.04	-	.72	1.64	-4.61	.00	-4.02	.01	4	-2.55	.26

Note. — The LM statistics for testing autocorrelation corresponding to the DF and ADF(1) are not significant at the 5 % level of significance; k is the optimal lag according to the AIC criterion.

The same conclusion is drawn from the cointegration residuals Durbin Watson (CRDW) test. The null hypothesis of this test is rejected for high values of DW . The high values of the Durbin Watson statistics show evidence of stationary residuals and thus of cointegrated variables.

However, we also apply the Johansen's Likelihood Ratio (LR) test to the growth rates of government expenditures and revenues. The results of this test are reported in Table 3. We conclude again that the variables are cointegrated, the cointegrating vector being (-10.79) .

Cointegration between government spending and taxes was found in other studies, as for example, Miller and Russek (1990), and Owoye (1995).

TABLE 3
Results of the LR cointegration tests of Johansen
(Maximal Eigenvalue and Trace tests)

Maximal Eigenvalue test				Trace test			
Null	Altern.	Stat.	Crit. val.	Null	Altern.	Stat.	Crit. val.
$r=0$	$r=1$	20.94	14.90	$r=0$	$r \geq 1$	23.98	17.95
$r \leq 1$	$r=2$	3.04	8.18	$r \leq 1$	$r=2$	3.04	8.18

Notes. — The maximum lag in the VAR is optimal according to the AIC criterion and is equal to 2; the critical value corresponds to the 5 % level of significance.

Since the variables are cointegrated, we know from Engle and Granger (1987) that there is at least a unidirectional causal relationship between the variables. For testing the existence of a causal link, we first apply the standard Granger causality test. The results are reported in Table 4 and show evidence of a causal relationship running from expenditures to tax revenues.

TABLE 4
Results of the standard Granger causality test

Indep. variables	Expenditures equation Dependent variable Δy_t			Revenues equation Dependent variable Δx_t		
	Coeff.	T-statistic	Sig. level	Coeff.	T-statistic	Sig. level
	Constant006	.564	.577	.008	.956	.350
Δy_{t-1}	-.642	-3.602	.001	.106	.639	.530
Δy_{t-2}	—	—	—	.614	3.250	.004
Δy_{t-3}	—	—	—	.369	2.052	.052
Δx_{t-1} .....	.119	.520	.607	-.811	-3.464	.002
Δx_{t-2}	—	—	—	-.897	-4.016	.001
Δx_{t-3}	—	—	—	-.324	-1.379	.182

Diagnostic statistics:

Expenditures equation: $\bar{R}^2 = .315$; DW = 1.800; F(2,28) = 7.885 (.002); SER = .063;
LM(1) = .209 (.647); LR(1) = .298 (.585);
Revenues equation: $\bar{R}^2 = .497$; DW = 1.907; F(6,22) = 5.615 (.001); SER = .043;
LM(1) = .003 (.956); LR(3) = 13.378 (.004).

Notes. — LM(p) is the Lagrange Multiplier statistic for testing error serial correlation of order p which has an asymptotic chi-square distribution with p degrees of freedom and in parentheses is the significance level; SER is the Standard Error of Regression; LR(k) is the Likelihood Ratio statistic for joint test of zero restrictions on the coefficients of the k deleted variables.

Now we apply the cointegration and error-correction methodology which allows a new source of causality due to the long run equilibrium relationship. The results of the estimation and testing of the error-correction models are presented in Table 5.

TABLE 5
Results of the error-correction models tests of causality

Indep. variables	Expeditures equation			Revenues equation		
	Dependent variable Δy_t			Dependent variable Δx_t		
	Coeff.	T-statistic	Sig. level	Coeff.	T-statistic	Sig. level
Constant .....	.006	.507	.616	.011	1.502	.146
Δy_{t-1}	-.516	-2.112	.044	-.499	-2.201	.038
Δy_{t-2}	-	-	-	.061	.338	.738
Δx_{t-1} .....	.014	.053	.958	-.039	.169	.867
Δx_{t-2}	-	-	-	-.420	-2.346	.028
\hat{u}_{t-1}	-.250	-.762	.453	-	-	-
\hat{v}_{t-1}	-	-	-	-.966	-3.018	.006

Diagnostic statistics:

Expeditures equation: $\bar{R}^2 = .304$; DW = 1.740; F(3,27) = 5.371 (.005); SER = .063;
LM(1) = .854 (.355); LR(2) = .957 (.620);
Revenues equation: $\bar{R}^2 = .557$; DW = 2.243; F(5,24) = 8.904 (.000); SER = .039;
LM(1) = 2.244 (.134); LR(3) = 17.678 (.001).

Notes. — LM(p) is the Lagrange Multiplier statistic for testing error serial correlation of order p which has an asymptotic chi-square distribution with p degrees of freedom and in parentheses is the significance level; SER is the Standard Error of Regression; LR(k) is the Likelihood Ratio statistic for joint test of zero restrictions on the coefficients of the k deleted variables.

From the results in this table we conclude again that there is causality from expenditures to tax revenues and that the link due to the long run equilibrium relationship is important. In sum, we concluded that a unidirectional causal relationship exists running from the expenditures to the revenues. Thus, the hypothesis of spend-and-tax seems to be verified for Portugal over the period 1958-1991, a result in opposition to the findings of Joulfaian and Mookerjee (1990b) for Portugal.

5 — Summary and conclusions

This paper investigated the causal relationship between government expenditures and tax revenues for Portugal over the period 1958-1991. The data used concern current expenditures and current tax revenues at current prices (nominal data). Data were converted to growth rates by considering the first differences of natural logarithms.

The methodology applied is the recent cointegration and error-correction modelling which provides additional channels through which causality could emerge.

The DF, ADF and the PP unit root tests were performed for testing the existence of unit roots of the levels, first and second differences of the logarithms of the expenditures and tax revenues series. The results of these tests showed that growth rates of expenditures and tax revenues are not stationary

but the changes of the growth rates are stationary. Hence, growth rates are integrated of order one, $I(1)$, the series in levels being $I(2)$.

The results of the Engle-Granger and Johansen tests of cointegration showed that the growth rates of the two variables are cointegrated. Hence, a causal relationship between government expenditures and tax revenues exists at least in one direction.

The estimation of an error-correction model showed that the causal relationship runs from expenditures to tax revenues and the additional causality channel referred above is significant.

The evidence of one way causality from expenditures to tax revenues implies that higher government expenditures lead to higher taxes. Thus, a cut in expenditures causes a cut in taxes and the deficit may not reduce. Thus, the safest solution for reducing the deficit is not a cut in expenditures but an increase in taxes.

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