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Persistence in Tax Revenues: Evidence from Some OECD Countries

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Abstract

This paper examines persistence in tax revenues in a set of 21 OECD countries over the period 1965-2021 using long-range dependence techniques based on fractional integration. The results imply that there are only a few cases of mean reversion: one for total revenue (Switzerland); three for VAT (Belgium, Italy, and Spain), and six for income (Austria, Belgium, Finland, Spain, Sweden and USA). The analysis is also carried out for inflation in the same set of countries and it is found to be mean reverting in all cases.

1. Introduction

This paper analyses the time series properties of tax revenues over the period from 1965 to 2021 in a set of 21 OECD countries. For this purpose we use a fractional integration framework which is more general than the standard one based on the stationary I(0) versus non-stationary I(1) dichotomy. In particular, it allows the differencing parameter d to take any real value, including fractional ones, as opposed to integers only. As a result, it allows for a much wider range of stochastic processes. Moreover, the estimated parameter d measures the degree of persistence of the series and sheds light on whether or not it is mean reverting. This provides useful information on whether the effects of shocks to the series will be transitory or permanent, which cannot be found in other studies using different methods such as unobserved components (Koopman and Ooms, 2003).

Given the recent surge in inflation, we also examine whether there exists a long-run relationship linking this variable to taxation. For instance, Patoli et al. (2012) found that the

t0 Tc 0 c 0.008 (M2o Td (y-1t)- Td [(G)2 (i3 o B1 (84.)]ct (n)2 (s)1 (h0 Tc 0.03 Tw [576 03.5 [(ru)-3 en

function which is unbounded at one or more frequencies in the spectrum. Alternatively, they are defined in the time domain as processes for which the infinite sum of the autocovariances is infinite. Within this category, a process is said to be fractionally integrated or integrated of order d, denoted by I(d), and where d can be any real number, if it can be expressed as

$$(1 - L)^{d} x(t) = u(t), \quad t = 1, 2, \ldots, \tag{1}$$

where L is the backshift operator ($Lx(t) = x(t-1)$) and u(t) is short memory or integrated of order 0, also denoted as I(0). For such a process the spectral density function is positive and bounded at all frequencies; this category includes the white noise and the stationary Autoregressive Moving Average (ARMA) class of models. However, if $d > 0$ in (1), x(t) becomes long memory because its spectral density function, f(.), tends to infinity at the frequency ($\lambda \to 0$) approaches zero, i.e.,

$$f(\lambda) \sim G\lambda^{-2d}, \quad \text{as } \lambda \to 0^{+}. \tag{2}$$

Fractional integration was originally introduced in Granger (1980) as a result of the observation that many aggregated data displayed a periodogram (which is an estimator of the spectral density function) with a very large value around the zero frequency, suggesting that the series should be differenced; however, after differentiation, the periodogram of the differenced series showed a value close to zero at such frequency, which

The estimation of the differencing parameter is carried out hereby means of the Whittle function, which is an approximation to the likelihood function of a stationary Gaussian time series in the frequency domain, using a version of a testing approach developed by Robinson (1994). This procedure has a number of appealing features, namely it has a standard null limit distribution, and it allows W R F R Q V L G H U D Q \ U H D O Y D O X H G L Q F O X G L Q J W K R V in addition, it is the most efficient method against local departures FROM WHAT???

3. Data

The series used for the analysis are tax revenue, VAT, and tax on income (both personal and corporate) in 21 OECD countries (Austria, Belgium, Canada, Denmark, Finland, France, Geermany, Greece, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK, US) at an annual frequency over the period 2019 1965-. We also construct inflation series as the percentage change in the Consumer Price Index (CPI) over the same period. All series are taken from the Organisation for Economic Co-operation and Development (OECD) database (https://data.oecd.org/). Since the original tax series are denominated in their national currency, to make them comparable they have been converted into euros for the countries with a different currency using the following exchange rates:

- Canada: 1 CAD = 0.68 EUR
- Denmark: 1 DKK = 0.13 EUR
- Japan: 1 JPY = 0.0068 EUR
- New Zealand: 1 NZD = 0.57 EUR
- Norway: 1 NOK = 0.087 EUR

- Sweden: 1 SEK = 0.088 EUR
- Switzerland: 1 CHF = 1.02 EUR
- Türkiye: 1 TRY = 0.047 EUR
- United Kingdom: 1 GBP = 1.14 EUR
- United States: 1 USD = 0.91 EUR

Figure 1 plots the total tax revenue, the US having the highest one.

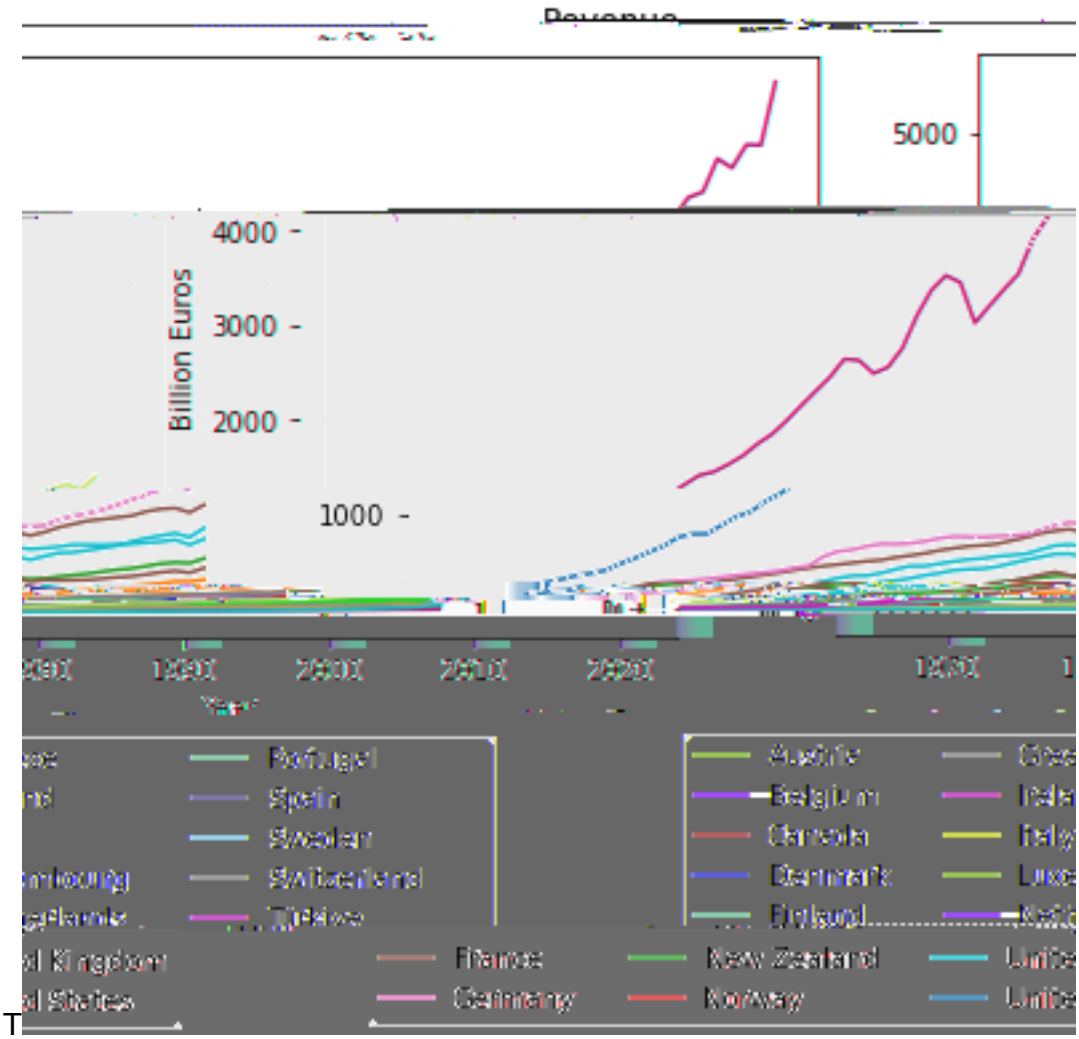

Figure 1: Time series of the total tax revenues in euros from the OECD countries with data since 1965.

Figure 2 displays instead the Value Added Tax (VAT) series. This source of tax revenue is highest in Germany[1].

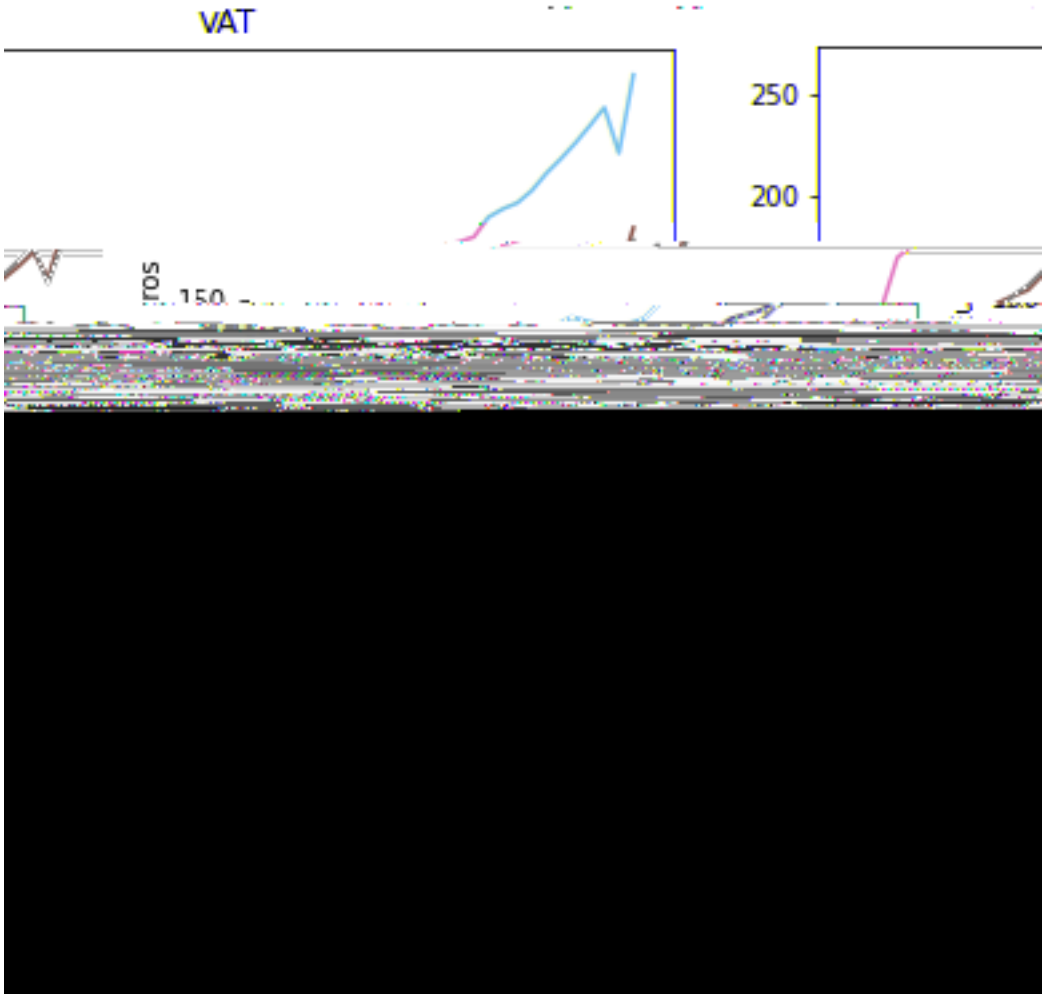

Figure 2: Time series corresponding to 1965-2021 value added taxes revenue of each OECD country in euros.

Figure 3 plots income tax revenue, with the US and Spain having the largest ones.

[1] Note that the US has a Sales Tax rather which is similar but not directly comparable to VAT.

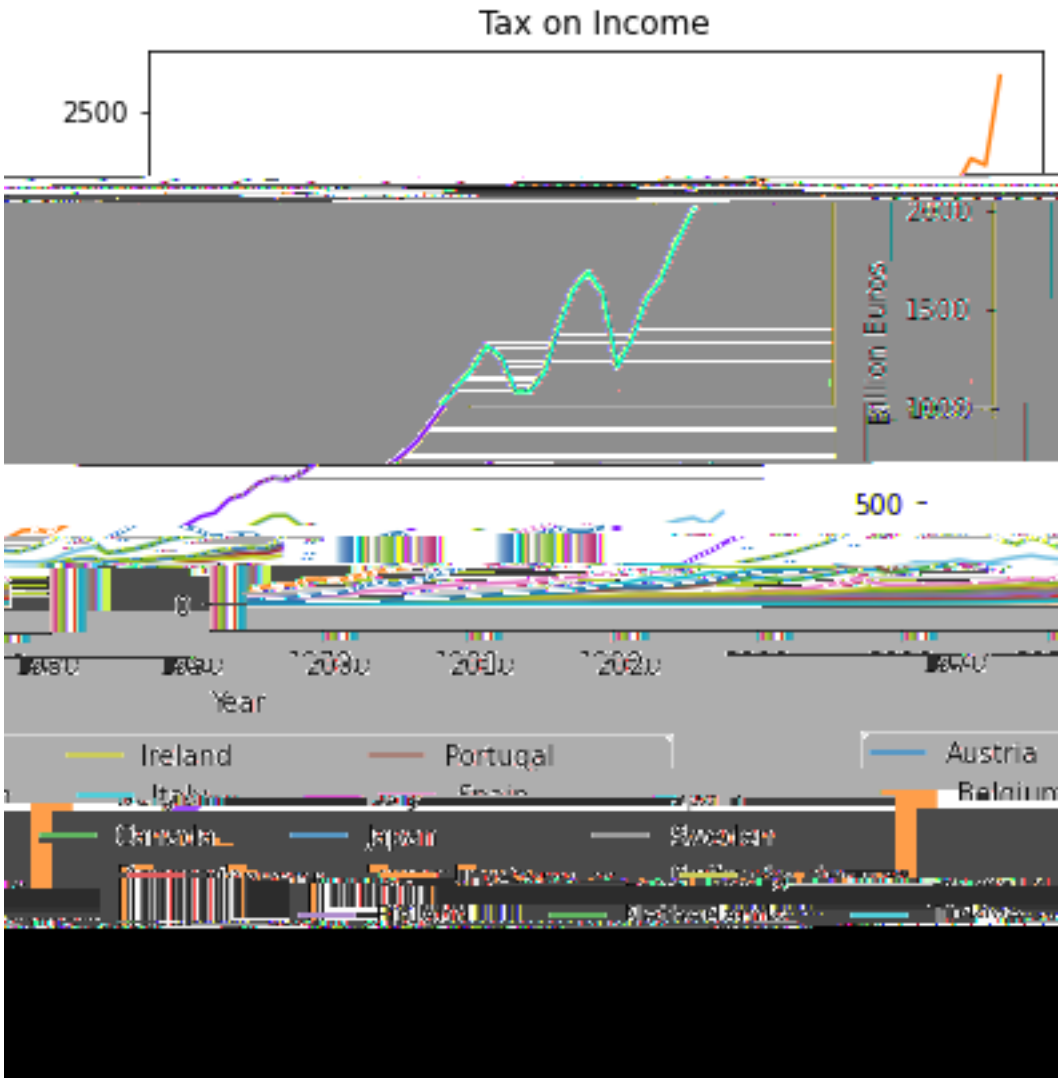

Figure 3: Time series of taxes on income, profits and capital gains revenues from OECD countries in euros until 2021.

4. Empirical Results

For our purposes, we examine the following model

$$(1-L)^{d} y_t = \alpha_0 + \alpha_1 t + \varepsilon_t, \quad (1-L)^{d} y_t = \varepsilon_t, \quad t = 1, 2, \ldots; \qquad (3)$$

where y_t refers to the observed data, α_0 and α_1 are the coefficients corresponding respectively to the intercept and a linear time trend, and ε_t is assumed to be I(d), where d is another parameter that is also estimated from the data. The error term is assumed to be a white noise process with zero mean and constant variance.

We estimate the differencing parameter d using three different model specifications:

i) with α_0 and α_1 being unknown and estimated along with d,

ii) $\alpha_1 = 0$ a priori, thus including an intercept only in the model, and

iii) with both α_0 and α_1 equal to zero a priori, thus not including any deterministic terms.[2]

The best specification is chosen by testing with values the significance of the respective coefficients.

Tables 1, 2, and 3 display the estimates of d along with the confidence bands corresponding to the non-rejection values of d at the 95% level for total, VAT, and taxon income revenues respectively. For each series,

TABLE 3: Estimates of the differencing parameter: TAX ON INCOME

Series	Model with no regressors	Model with a constant	Model with a constant and a linear time trend
AUSTRIA	0.86 (0.95, 0.98)	0.90 (0.80, 1.01)	0.74 (0.50, 0.99)*
BELGIUM	0.82 (0.72, 0.94)	0.88 (0.78, 0.98)	0.41 (0.11, 0.84)*
CANADA	0.87 (0.73, 1.03)	0.89 (0.77, 1.04)	0.69 (0.36, 1.04)
DENMARK	0.98 (0.84, 1.42)	0.98 (0.83, 1.44)	0.97 (0.67, 1.51)
FINLAND	0.81 (0.69, 0.99)	0.83 (0.72, 1.01)	0.54 (0.08, 0.97)*
FRANCE	0.88 (0.75, 1.05)	0.89 (0.77, 1.07)	0.77 (0.48, 1.08)
GERMANY	0.80 (0.66, 1.02)	0.87 (0.72, 1.08)	0.76 (0.47, 1.09)
GREECE	1.35 (1.10, 1.68)	1.35 (1.10, 1.68)	1.35 (1.09, 1.66)
IRELAND	1.02 (0.76, 1.55)	1.03 (0.76, 1.55)	1.00 (0.63, 1.51)
ITALY	1.05 (0.90, 1.30)	1.05 (0.90, 1.30)	1.04 (0.79, 1.30)
JAPAN	1.33 (1.10, 1.74)	1.33 (1.10, 1.74)	1.31 (1.09, 1.73)
LUXEMBOURG	1.23 (1.05, 1.46)	1.25 (1.06, 1.47)	1.29 (1.05, 1.49)
NETHERLANDS	1.21 (0.78, 1.72)	1.21 (0.72, 1.80)	1.22 (0.81, 1.79)
NEW ZEALAND	1.06 (0.51, 1.78)	1.02 (0.47, 1.77)	1.09 (0.61, 1.76)
NORWAY	0.80 (0.65, 1.22)		

(1.31), and Portugal (1.25). Moreover, evidence of mean reversion ($d < 1$) is found only in the case of Switzerland (0.80). For VAT, the values are generally lower, and mean reversion now takes place for Belgium ($d = 0.72$), Italy (0.69)

TABLE 4: Summary of the results for d

Series	Revenue	VAT	Tax on income

Next, we incorporate inflation into the analysis. Figure 4 shows that Turkey has the highest rate among the 21 countries considered.

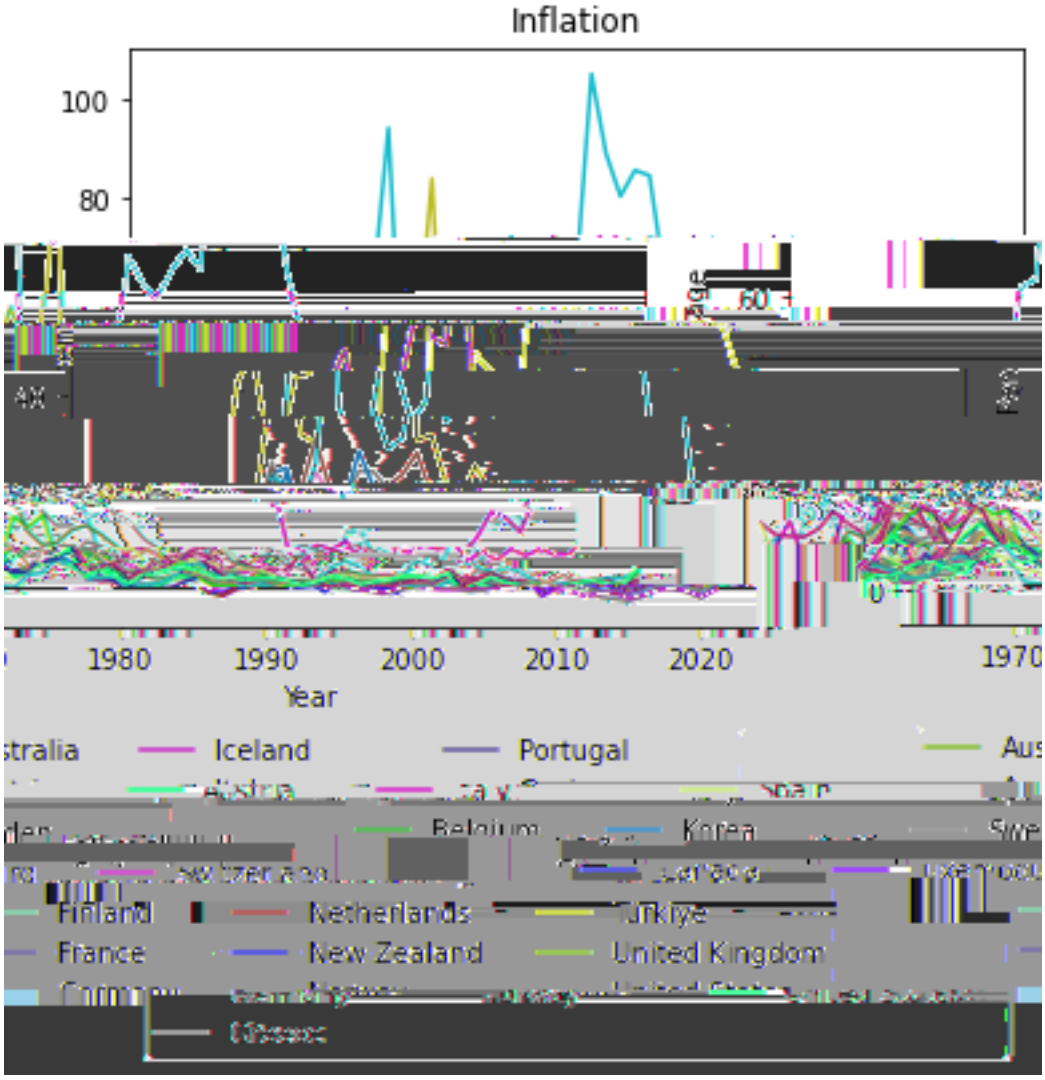

Figure 4: Time series of the OECD countries' annual inflation rate since 1965.

Table 5 and 6 report respectively the estimates of d from the three specifications being considered and the corresponding estimates from each regression model. Again, the coefficients in bold are those from the selected specification.

Table 5: Estimates of the differencing parameter: Inflation

Series	Model with no regressors	Model with a constant	Model with a constant and a linear time trend
AUSTRALIA	0.92 (0.74, 1.23)	0.87 (0.68, 1.19)	0.87 (0.67, 1.19)
AUSTRIA	0.80 (0.64, 1.06)	0.72 (0.54,1.06)	0.71 (0.47, 1.06)
BELGIUM	0.93 (0.71, 1.33)	0.87 (0.62, 1.28)	0.86 (0.58, 1.28)
CANADA	0.99 (0.80, 1.35)	0.92 (0.71, 1.28)	0.92 (0.69, 1.28)

Table 6: Estimated coefficients of the selected models: Inflation

integration is within the unit root interval, the highest values being estimated for Italy (1.02), France (1.04), and Luxembourg (1.05).

Next, we focus on whether there is a relationship linking the tax series and inflation. Table 7 shows the correlation coefficients for each of the 21 OECD countries considered. It can be seen that all the values are positive and close 1, which indicates a very strong correlation.

TABLE 7: Correlation between inflation and revenues

Series	Revenue	VAT	Tax on income
AUSTRIA	0.99	0.99	0.98
BELGIUM	0.98	0.98	0.99
CANADA	0.97	0.99	0.96
FINLAND	0.96	0.94	0.97
FRANCE	0.97	0.98	0.93
GERMANY	0.98	0.98	0.96
GREECE	0.98	-----	0.97
ITALY	0.99	0.99	0.99
LUXEMBOURG	0.92	0.92	0.91
NETHERLANDS	0.98	0.97	0.95
PORTUGAL	0.97	0.98	0.97
SWEDEN	0.95	0.91	0.96
TURKEY	0.98	-----	0.97
NORWAY		-----	

To test more rigorously for the existence of a long-run relationship between tax revenues and inflation one could use fractional cointegration methods. Engle and Granger (1987) defined cointegration in a bivariate context as a situation where the two individual series are integrated of order d, i.e., I(d), but there exists a linear combination of the two which is integration of a smaller order, say, d – b with b > 0. Though they define this concept for any real values of d,

TABLE 11: Summary of the results for d: deflated series

Series	Revenue	VAT	Tax on income
AUSTRIA	0.66 (0.52, 0.88)*	0.50 (0.38, 0.67)*	0.42 (0.24, 0.69)*
BELGIUM	0.88 (0.71, 1.13)	0.50 (0.33, 0.74)*	1.01 (0.85, 1.24)
CANADA	0.94 (0.61, 1.42)	0.51 (0.24, 0.87)*	0.89 (0.68, 1.21)
FINLAND	0.93 (0.64, 1.33)	1.41 (1.00, 1.93)	1.21 (0.74, 1.84)
FRANCE	0.71 (0.51, 1.04)	0.81 (0.62, 1.06)	0.86 (0.68, 1.18)
GERMANY	1.02 (0.82, 1.32)	0.79 (0.50, 1.28)	0.88 (0.68, 1.21)
GREECE	1.22 (1.04, 1.50)	-----	0.97 (0.83, 1.16)
ITALY			

7. Conclusions

This paper examines the stochastic behaviour of tax revenues in 21 OECD countries over the period 1965-2021 using a fractional integration approach. More specifically, the fractional differencing parameter d is a measure of persistence; it also sheds light on whether or not mean reversion occurs and shocks have transitory or permanent effects. The results indicate that most of the series exhibit long memory. Also, in most cases the selected model specification includes a time trend, the exceptions being the Netherlands in the case of the VAT series, Greece and Turkey in the case of both total tax revenue and tax on income, Japan and New Zealand in the latter case only. In most cases the unit root null hypothesis cannot be rejected, and in a few cases such as the Netherlands and New Zealand d is even above 1.

As for the inflation series, the I(1) hypothesis cannot be rejected for the majority of the countries, mean reversion only occurring in the cases of Korea, Iceland, Norway and Sw s b4 (s)-1 (e)

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