CREDIT-TO-GDP RATIOS. NON-LINEAR TRENDS AND PERSISTENCE: EVIDENCE FROM 44 OECD ECONOMIES

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ABSTRACT

In this article we investigate the degree of persistence in the credit-to-GDP ratio in 44 OECD economies in the context of nonlinear deterministic trends. In particular, we use Chebyshev's polynomials in time, which allow us to model changes in the data in a smoother way than by structural breaks. Our results indicate that approximately one quarter of the series display non-linear structures, and only Argentina displays a mean reverting pattern. Policy implications of the results obtained are discussed at the end of the manuscript.

Keywords: Chebyshev polynomials; fractional integration; persistence; private debt

JEL Classification: C22, G30, G51

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1. Introduction

The Great Leveraging (Taylor, 2014) was a period where fast growth of credit hand in hand with rapid house price growth was observed amongst many peripheral European economies, Cuestas and Staehr (2017). The Global Financial Crisis after the Great Leveraging and the Global Savings Glut, along with low interest rates worldwide in the 2000s, led to the misallocation of foreign capital in high bubbling markets which exploded in 2008 after the Lehman Brothers crash in the US (Bernanke, 2005). In the most affected European countries, the so-called GIIPS (Greece, Ireland, Italy, Portugal and Spain), the housing market was boosted by an increase in private credit. This, in turn, was accompanied by significant current account deficits induced by foreign capital inflows in these countries (Gossé and Serranito 2014; Carvalho, 2019).[1] However, after this period high economic growth worldwide, the situation was totally reversed with a deleveraging process that caused enormous stagnation in most economies (Reinhart and Rogoff, 2014). The Fisher deflation effect played a key role in the bust of housing markets and the sudden stops of international capitals exacerbated the situation (Dimand, 1994).

Therefore, it is of great policy importance to analyse the behaviour of credit to the private sector, since, as has been argued, this can help predict financial crises (Gourinchas and Obstfeld, 2012; Jordá et al. 2013; Taylor, 2014; Jordá et al. 2015). Hence, knowing whether credit is a mean reverting process or not can give us hints on how the authorities should react after a credit shock. If credit follows a non-mean reverting process, when a shock hits the economy the variable will forever deviate from its initial equilibrium path and, policy intervention will be necessary to restore the pre-shock values of the credit-to-GDP ratio. In such a case, close monitoring of credit growth by the policy authorities is imperative. If, credit follows a mean reverting process, the variable will return to its

[1] See Cuestas (2017) for the case of Spain.

equilibrium path after any shock, and policy intervention does not appear to be necessary. However, the current paper goes further and assesses the reasons that may lead a country to exhibit a mean-reverting credit-to-GDP ratio. Whether the variable is issued in one currency or another is determinant for the policy implications derived by this analysis.

In this paper we analyse the univariate statistical properties of the credit variable by means of estimating its order of integration *d* in an *I(d)* context where d can be a fractional number. Hence, if $d < 1$ the variable is a mean reverting process, whereas if $d \geq 1$ the variable will not revert to the equilibrium after a shock. In addition, covariance stationary takes place if $d < 0.5$, while $d \geq 0.5$ implies nonstationarity. Also, the higher the value of *d*, the higher the level of nonstationarity (Contreras-Reyes and Palma, 2013). Typically, this analysis is carried out by means of unit root tests. If the process contains a unit root, we say that the process is *I(1)* and shocks have permanent effects over the variable. If the variable is stationary *I(0)* then shocks only have transitory effects and it will come back to the equilibrium path after a shock. However, in this paper we employ fractional integration methods which break the dichotomy between *I(0)* and *I(1)*, allowing for non-integer values of *d*. In addition, and given the potential cyclical behaviour of the variable, we incorporate non-linear deterministic trends to the model, proxied by Chebyshev polynomials in time. For this purpose, we apply the recently developed fractional integration analysis of Cuestas and Gil-Alana (2016). To our knowledge, we are the first to use this fractional integration methods for the analysis of non-linear trends of the credit-to-GDP ratio. It is well known that not accounting properly for the deterministic components may affect the power of the tests, hence, making the results biased towards less stationary processes (see Perron, 1989; Phillips and Xiao, 1999; Kim et al., 2004, amongst many others).

We estimate the value of *d* for a group of 43 OECD countries and the Eurozone for the private credit-to-GDP ratio using data from the Bank of International Settlements. As mentioned before, this analysis can yield important policy implications. Our results highlight the fact that in most of the cases analysed the credit-to-GDP ratio is not a mean reverting process, meaning that the authorities need to monitor closely the evolution of this variable to prevent an escalation of excess of credit and avoid bubbles.

The remainder of the paper is organised as follows. The next section provides a brief literature review on the subject. Section 3 explains the econometric method applied in this paper. Section 4 describes the data. Section 5 summarises the results and, finally, the last section concludes the paper.

2. A short review of the literature

An extensive and very recent literature finds a connection between the health of the economy and private credit dynamics (Kiyotaki and Moore, 2002, Raberto et al., 2012, Verner, 2019 or the empirical study of Chen et al., 2015, among others). Levine (2005) positively relates the behaviour of the financial system to GDP growth and uses private debt-to-GDP as a proxy for such financial development. Estrada et al. (2014) study through cross-country evidence the importance of private debt fluctuation for the economic recovery after the Global Financial Crisis. At a theoretical level, Andrés et al. (2020) analyse the effects of the private deleveraging process following the 2007 financial on the restitution of the GDP pre-crisis levels. Eggertsson and Krugman (2012) find that the deleveraging process has only temporary –negative– effects on economic activity thus, they suggest implementing temporary measures to counteract the fall of private debt. Batini et al. (2019) explain that increases of government debt to reduce private deleveraging can make recessions more severe due to a minor fiscal accommodation

accompanied by that private deleveraging process. We go further with our research and investigate whether the effects of any shock on private debt are permanent or not, which is also useful to determine the policy response (see also Caporale et al., 2021). It seems clear that policymakers should consider private debt properties in order to stabilise the business cycle and achieve sustainable growth.

In line with the latter papers, Ivens (2018) studies the optimal fiscal policy that compensates the welfare losses caused by a deleveraging shock. Benigno et al. (2020) develop a new Keynesian model to assess the effects of optimal monetary policy on dynamic private deleveraging and the business cycle after a recession. But, as recent policy studies acknowledge (Quint and Rabanal, 2014; Rubio and Carrasco-Gallego, 2014; Brzoza-Brzezina et al., 2015), also macroprudential tools should aim to stabilize the path of credit to the private sector. This branch of literature has become very important especially since the wake of the Great Recession. In particular, Bole et al. (2014), Matheron and Antipa (2014) or Dehmej and Gambacorta (2019) state that macroprudential policy sustains monetary policy actions and mitigates the negative effects of private deleveraging. De Blas and Malmierca (2020) analyse counter-cyclical macroprudential measures boosting private debt during recessions and restraining it during booms. They show that, after financial shocks, the policy mix needs to include macroprudential policy to stabilize private and public debt at the same time. All the above papers, advocate the need to implement macroprudential measures to maintain a stable private debt. We complement their results by analysing the properties of private debt in 43 OECD countries and the Eurozone, providing the initial framework to start deciding on how to use this novel policy.

As explained above, this paper analyses private debt persistence and non-linearity using fractional integration methods. Therefore, our works also fits in with the literature

that studies the persistence or long memory properties of financial market variables. Assaf (2007) investigates the long memory in the Middle East and North African equity markets returns and volatility. Caporale et al. (2018) apply fractional integration methods to analyse the statistical properties of Emerging Market Bond Index, while Caporale et al. (2020) replicate the latter for European stock market indices. Unlike them, we study the persistence of private credit-to-GDP through the evidence provided from 44 OECD economies in a potential non-linear framework.

Caporale et al. (2021) analyse the persistence properties of private debt-to-GDP for 43 OECD countries based on historical data, using linear approximations for the time trend. Our study seeks to expand the results obtained in the aforementioned work by studying the non-linearities of the private credit-to-GDP ratio, in line with the non-linear approach proposed in Cuestas and Gil-Alana (2016) and based on Chebyshev polynomials in time.

There is a scarce but interesting literature that examines the non-linearities of debt. Eberhardt and Presbitero (2015) implement linear and non-linear approaches to establish a relation between public debt and economic growth, and Canner et al. (2018) use 29 OECD countries and find evidence of a non-linear relation between private and public debt interaction and economic growth. As far as we know this is the first paper to investigate the private credit-to-GDP ratio with a non-linear model in a fractionally integrated framework.

3. Methodology

We use techniques based on fractional integration. Thus, we allow for potential fractional values in the degrees of differentiation of the series to render it stationary *I(0)*. In other

words, we say that a time series x_t, t= 1, 2, … is fractionally integrated or integrated of order *d*, and denoted by *I(d)*, if its *d*-differences is *I(0)*, i.e.,

$$(1 - L)^d x_t = u_t, \qquad t = 1, 2, \dots, \tag{1}$$

where *L* refers to the lag-operator, i.e., $Lx_t = x_{t-1}$ and u_t is *I(0)*. Whitin the latter group of models (*I(0)*) we can include the white noise and the stationary and invertible autoregressive and moving average (*ARMA*) processes. These models are very flexible and permit us to determine if shocks in the series will have temporary or permanent effects depending whether the value of the differencing parameter (*d*) is smaller than 1 (transitory shocks) or equal to or higher than 1 (permanent shocks). In this context, we also allow for nonstationary mean reverting patterns if the parameter *d* is in the range [0.5, 1).[2] In addition, they are more general than other models like those based on unit root tests that simply consider the cases of $d = 0$ for stationarity and $d = 1$ for unit roots.

Nevertheless, some authors have argued that fractional integration can spuriously be produced by the presence of non-linearities in the data that have not been considered (Granger and Hyung, 2004; Kuswanto and Sibbertsen, 2008; Ohanissian et al., 2008; etc.). For this purpose, we use in this paper a non-linear trend model that allows for fractional integration. In particular, we use Chebyshev's polynomials in time using the approach developed in Cuestas and Gil-Alana (2016).

The model is given by:

$$y_t = \sum_{i=0}^{m} \theta_i P_{iT}(t) + x_t, \quad (1 - L)^d x_t = u_t, \qquad t = 1, 2, ..., \tag{1}$$

where y_t is the observed series, and P_{iT} are the Chebyshev time polynomials defined by:

$$P_{0,T}(t) = 1,\ P_{i,T}(t) = \sqrt{2}\cos\left(i\pi(t-0.5)/T\right), \qquad t = 1, 2, \dots, T; \quad i = 1, 2, \dots,$$

[2] In the *I(d)* framework, mean reversion takes place when the differencing parameter d is smaller than 1, while lack of it occurs if $d \geq 1$ (Vera-Valdes, 2021).

where m indicates the degree of non-linearity.[3] According to Bierens (1997), Tomasevic and Stanivuk (2009) and others it is feasible to approximate highly non-linear trends with rather low degrees of these polynomials. Thus, if $m = 0$ the model contains a constant, if $m = 1$ it contains a constant and a linear time trend, and if $m > 1$ it becomes non-linear, and the higher m is the less linear the approximated deterministic component becomes. The full description of the procedure employed in this work can be found in Cuestas and Gil-Alana (2016) and is basically an extension of a simple version of the tests of Robinson (1994) to the non-linear case that uses the Whittle function expressed in the frequency domain.

This methodology that uses fractional integration makes sense in the context of the credit-to GDP ratios because it can determine from the data if exogenous shocks will have permanent or transitory effects depending on the value of d. Thus, for example, if the shock is negative and the estimate of d is equal to or higher than 1, strong policy actions must be conducted to recover the original long term projections; however, if the differencing parameter is significantly smaller than 1, mean reversion takes place, not requiring then strong policy actions since the series returns by itself to it long run trend.

4. Data description

We use quarterly data corresponding to the private credit-to GDP ratio for 43 OECD countries and the Eurozone for the period 1947-2020. More concretely, we work with credit to the private non-financial, from all sectors of the economy, to-GDP ratio. The series used are available at the Bank of International Settlements (BIS) Statistics Warehouse. In particular, BIS statistics contain series that are compiled in cooperation with central banks and other national authorities.

[3] A very detailed description of the Gegenbauer polynomials can be found in Hamming (1973) and Smyth (1998).

The 44 OECD countries/regions considered are the following: Argentina, Austria, Australia, Belgium, Brazil, Canada, Switzerland, Chile, China, Colombia, Czechia, Germany, Denmark, Spain, Finland, France, theUnited Kingdom, Greece, Hong Kong, Hungary, Indonesia, Ireland, Israel, India, Italy, Japan, Korea, Luxembourg, Mexico, Malaysia, Netherlands, Norway, New Zealand, Poland, Portugal, Russia, Saudi Arabia, Sweden, Singapore, Thailand, Turkey, the United States, the Eurozone and South Africa.

Figure 1 depicts the mean and variance of the quarterly time series on private debt-to-GDP for the economies for which there are less than 200 observations available. Figure 2 displays the same statistics for the group of economies for which we could collect data for 200 quarters or more.

Figure 1: Mean and variance of the time series with less than 200 observations

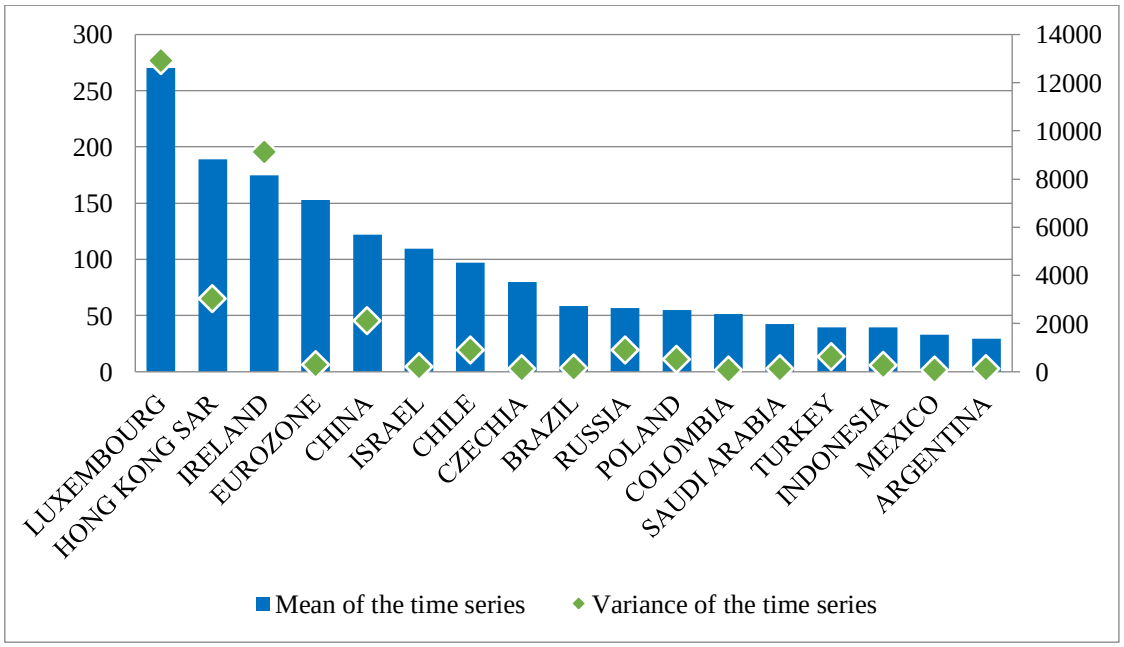
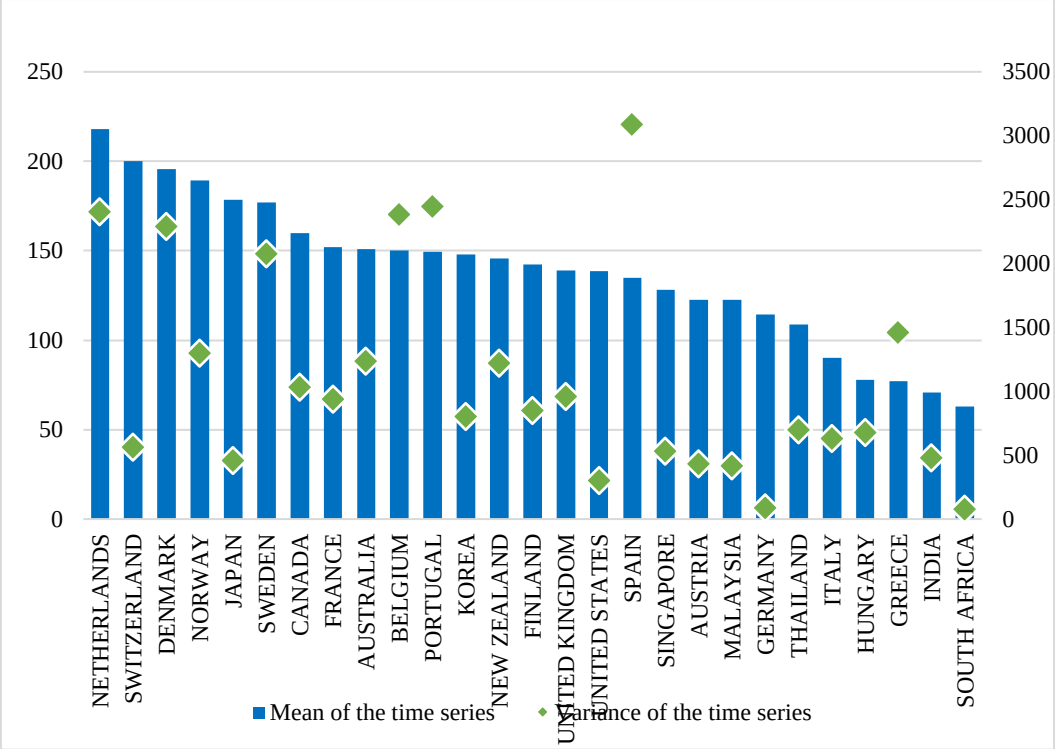


Figure 2: Mean and variance of the time series with 200 observations or more



All countries provide data up to the third semester of year 2020. We can distinguish different groups with regards to the amount of debt over their GDP and, surprisingly, they are not the usual suspects (Regis et al. 2015). On the one hand, we find that Australia, Canada, Switzerland, Luxembourg or Hong Kong carry large debt-to-GDP ratios. On the other hand, Greece for example only appears to have an average of the debt-to-GDP ratio around 77% throughout the whole period, Italy around 90%, and Colombia and Brazil just above 50%. It is noticeable that, in most cases, countries with higher debt-to-GDP ratios present larger volatility during the period analysed.

5. Empirical results

Table 1 displays the estimated coefficients of the model given by equation (1) under the assumption of white noise errors. We display in column 2 the estimates of the differencing parameter *d* (and its 95% confidence interval). The remaining four columns report the

estimates of the Chebyshev coefficients and, if either of the last two (θ_2 and/or θ_3) are statistically significant, we will obtain evidence of nonlinearity in its behaviour.

TABLE 1 ABOUT HERE

We first focus on the estimated values of d. Evidence of mean reversion (i.e., $d < 1$) is only found in the case of Argentina with an estimated value of d equal to 0.58; the unit root null hypothesis cannot be rejected in 12 series (Austria, Belgium, Brazil, Czechia, India, Indonesia, Ireland, Israel, Luxembourg, New Zealand, Russia and Turkey); for the remaining 32 series, the estimated values of *d* are significantly higher than 1. Thus, we only observe as single case displaying a mean reverting pattern, Argentina.

If we focus now on the Chebyshev coefficients, strong evidence of a non-linear patter (i.e., both θ_2 and θ_3 statistically significantly different from 0) is obtained for Czechia, Germany and Turkey. However, there is also a group of countries where also one of the two coefficients which is significant. They are Belgium, Brazil, Colombia, Eurozone, Greece, India, Ireland, Italy, and Japan (with significant θ_2) along with Hong Kong where θ_3 is the significant one. For the remaining countries (30 in total out of the 44 series examined) both coefficients are statistically insignificant, providing no evidence of non-linearities.

TABLE 2 ABOUT HERE

We next repeat the same experiment but allowing for autocorrelation in the error term. Here, autocorrelated is described by means of the model of Bloomfield (1973) that approximates autoregressive (*AR*) structures in a non-parametric way. Once more Argentina is the only country showing evidence of mean reversion. The estimates of *d* are generally very similar to those reported in Table 1. Greece and Turkey are now the only two countries with both non-linear coefficients being statistically significant and at

least one significant coefficient is found in the cases of Belgium, Brazil, the Eurozone, Germany, Greece, India, Ireland, Israel, Italy and Japan (i.e., the same countries as in Table 1 except for Colombia were now both coefficients are insignificant). Thus, only approximately one quarter of the countries examined display some nonlinearity, though the conclusions do not differ much from those based on a linear model (see Caporale et al., 2021) and Argentina seems to be the only country displaying reversion to the mean. Tables 3 and 4 summarise the results obtained across the paper.

TABLES 3 AND 4 ABOUT HERE

The results obtained for Argentina are not surprising if one observes the evolution of this country's private credit-to-GDP ratio. The extremely high values of 2002-2004 are explained by the economic crisis that started at the end of 2001 with the collapse of the currency board system prevailing since 1991, which meant an important reduction in GDP during 2002 and more importantly a massive devaluation of the local currency (approximately 300%). This, combined with the fact that most of the public debt was issued in foreign currency, implied an explosion of the variable. But the country quickly converged to more normal values of the credit-to-GDP ratio after a massive debt restructuring in 2005, as well as experiencing significant growth rates and stabilization of the local currency. This is consistent with the results in Caporale et al. (2021). Although one may be tempted to assert that, given the results, Argentina should not worry about debt accumulation, since after a shock it will tend to revert to equilibrium, actually it is not like that. The main problem is not the size of the private credit-to-GDP ratio, but the currency in which it is issued. Argentina consistently faces difficulties in generating foreign currency inflows, either through exports or through foreign direct investment, to meet its foreign currency obligations. It should also be recalled that in February 2014, after numerous failed measures to restrict capital outflows, the government was forced to

carry out a 40% devaluation of its currency (later compensated by an increase in prices). In 2018, the Argentine government's inability to reduce persistently high inflation, plus the increased volatility in international financial markets, unleashed additional pressures on the foreign exchange market that caused the local currency to collapse. This situation forced the national government to request a new loan from the International Monetary Fund. In 2020, a new debt restructuring with private creditors was carried out, while the negotiations with the IMF are expected to conclude shortly.

The countries highlighted in the third column of Table 4, purely explosive processes, are those which suffered from high ratios or with relatively high volatilities. Those countries should monitor closely their debt accumulation, since any shock, in particular a positive one, may have catastrophic effects over their accumulated debt. For example, a shock similar to the COVID-19 pandemic may accumulate effects if authorities do not correct it with an exogenous economic policy. Perhaps, a lower effort needs to be placed by the countries in the second column which shows the ones with a unit root behaviour. In such a case, the effect of a shock on the variable will have permanent effects, but not as explosive as in the case of countries in column 3. We are talking about countries with mild volatilities and not too high debt ratios. Finally, the countries in the last column are the ones showing evidence of nonlinear deterministic trends. Although not within the scope of the present study, these nonlinearities may be related to an excess of counter-dependence with GDP, implying that these countries could use their economic cycle as a predictor of the evolution of their credit-to-GDP ratios.

6. Conclusions

We have examined in this paper the credit-to-GDP ratios in 44 OECD economies by testing their degree of integration in the context of non-linear deterministic trends. We

use an approach developed in Cuestas and Gil-Alana (2016) that allows for non-linear trends based on Chebyshev polynomials in time, with the residuals being fractionally integrated or integrated of order *d*, where *d* can be any real value.

Our results first indicate that mean reversion (or estimates of *d* significantly below 1) is only obtained in the case of Argentina, what holds independently of the way of modelling the error term, and thus implying transitory effects of shocks in the series. This result suggests two main conclusions. First, that despite the immediate consequences on private debt of any kind of shock, Argentina was able be able to revert its credit-to-GDP ratio after a series of defaults and debt restructuring negotiations. Second, economic policies aimed at debt stabilization, such as macroprudential measures, would not be as effective in Argentina as in other economies that do not exhibit mean reversion. In all the other countries examined, the estimates of *d* are equal to or higher than 1, thus showing evidence against this hypothesis. Nonlinear trends are found to be significant in about twelve economies out of the 44 examined. In particular, for Belgium, Brazil, the Eurozone, Germany, Greece, India, Ireland, Israel, Italy and Japan, and also for Colombia if the errors are uncorrelated. For the remaining cases shocks will have permanent effects, based on the high degree of dependence observed in the data. Policy makers should react accordingly to shocks that destabilize the private debt-to-GDP ratio in these countries, keeping in mind that their action is key to restore equilibrium. The fact that we find evidence of non-linear trends is key to understanding the behaviour of this variable. On the one hand, it evidences that during the more than fifty years analysed there have been structural changes in the data which are well proxied by these trends. On the other hand, it shows that ignoring those non-linear trends may affect the estimation of the order of integration, and hence, policy resolutions based on that may be misplaced.

A promising topic for further research could be the joint analysis of non-linear trends in public debt and the connection of those results with the non-linearities observed in our analysis for the private debt series. This might be interesting to contrast the findings of a strand of the literature that examines the link between the correlation of private and public debt and economic activity (see Batini et al., 2019 or de Blas and Malmierca, 2020). In addition, other nonlinear deterministic trend approaches in the context of *I(d)* models, such as those based on Fourier transformations (Yaya et al. 2021) can also be implemented on these and another data.

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