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Abstract

This paper investigates the degree of persistence of the private debt-to-GDP ratio in 43 OECE countries by estimating the fractional integration parameter of each series. Almost all of them are found to be highly persistent, with orders of integration around or above 1. The only exception is Argentina, where the series appears to be mean-reverting. These results highlight the key importance of macroprudential policy as one of the pillars of macro policy.

JEL Codes: C220, G300, G510.

Keywords: persistence, fractional integration, private debt.

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1. Introduction

The 2007-8 global financial crisis (GFC) brought once again to the fore the importance of financial stability. One of the key aspects of the crisis was the fact that credit to the private sector was frozen, which led to a sharp fall in both private consumption and investment and thus in the growth rate of GDP. Having originated in the US as a subprime mortgage crisis, it quickly spread across the globe reducing lending and resulting in private sector deleveraging.

This paper investigates the statistical properties of the private debt-to-GDP ratio in 43 OECD countries with the aim of gaining a deeper understanding of its behaviour during the GFC. More specifically, the analysis uses a fractional integration approach to estimate the degree of persistence of the series of interest and to shed light on whether the effects of shocks hitting them are transitory or permanent. This type of framework is more general and flexible than the standard one based on the I(0) versus I(1) dichotomy since it allows not only for integer degrees of integration but also for fractional ones, and thus it considers a much wider range of stochastic processes. To our knowledge, no previous study has applied such methods in the case of the private debt-to-GDP ratio (Ramalho and Silva, 2009, focused on firms only).

The results are informative about cross-country differences possibly accounting for the different impact of the GFC and can also be used for developing an appropriate macroprudential framework for safeguarding the stability of the financial system. This should involve monitoring private debt indicators to avoid excessive borrowing and policies such as countercyclical capital requirements or dynamic provisions to boost private debt and encourage private investment and consumption during recessions.

The layout of the paper is as follows. Section 2 briefly reviews the relevant literature. Section 3 outlines the methodology. Section 4 presents the data and the empirical findings. Section 5 summarises the main findings and discusses their policy implications.

2. Literature Review

Numerous studies have concluded that private debt plays a crucial role in business cycle dynamics – see, for instance, Kiyotaki and Moore (2002), Koo (2008), Raberto et al. (2012) and Chen et al. (2015) among others. There is also an extensive literature focusing more specifically on the private deleveraging process that followed the GFC and its effects on the GDP path. Estrada et al. (2014) presented cross-country evidence of the relevance of the level of private debt for the slow recovery of consumption after 2008. Andrés et al. (2020), using a general equilibrium model, found that there is a relation between the size and speed of fiscal consolidations and the duration of private deleveraging; they argued that, after a negative shock to the economy, fiscal tightening results in private deleveraging and lower economic growth.

Eggertsson and Krugman (2013) developed a new Keynesian model to show that the negative effects of deleveraging on spending and output might be only temporary, which should be taken into account by policy makers. They also showed that the level of debt initially held by households is crucial in terms of the effects of deleveraging. Ivens (2018) also analysed the role of policymakers in counteracting the welfare losses caused by a deleveraging shock and the issue of the optimal fiscal policy response to a private debt crisis.

Another strand of the literature examines macroprudential tools to stabilise private leverage (Quint and Rabanal, 2014; Brzoza-Brzezina, Kolasa and Makarski, 2015; Rubio and Carrasco-Gallego, 2014). In particular, de Blas and Malmierca (2020), Bole et al. (2014) and Dehmej and Gambacorta (2017) all argued that, after financial shocks such as the GFC, the traditional monetary-fiscal policy mix needs to be complemented by macroprudential policies aimed at stabilizing both private and public debt.

Finally, Ramalho and Silva (2009) examined the determinants for the financial leverage decisions of firms using a fractional regression model and found that different factors determine whether or not debt is issued and the amount issued respectively.

3. Methodology

This section outlines the fractional integration framework used for the analysis. A series is said to be fractionally integrated or integrated of order d, i.e., I(d), if it can be represented as:

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

where B is the backshift operator, i.e. $B^k x(t) = x(t-k)$, u(t) is I(0) or short memory (either a white noise or weakly autocorrelated as in the stationary ARMA processes) and where d can be any real value. Earlier studies assumed that d is equal to either 0 (stationarity) or 1 (non-stationarity) and carried out unit root tests to distinguish between these two cases (Dickey and Fuller, ADF, 1979; Phillips and Perron, PP, 1988; Kwiatkowski et al., KPSS, 1992; Elliot et al., ERS, 1996; Ng and Perron, NP, 2001; etc.). However, the differencing parameter d can also be a fractional value in the interval (0, 1) or even above 1. In such a case, the polynomial in B in (1) can be expressed in terms of a Binomial expansion such that, for all real d:

$$(1 - B)^d = \sum_{j=1}^{\infty} \binom{d}{j} (-1)^j B^j = 1 - d\,B + \frac{d(d-1)}{2} B^2 - \frac{d(d-1)(d-2)}{6} B^3 + \ldots.$$

The higher the value of d is, the higher is the degree of dependence between the observations; d is also a measure of persistence. The following cases can be considered:

1) short-memory processes, if d = 0,

2) long-memory stationary processes, if $0 < d < 0.5$,

3) nonstationary mean-reverting processes ($0.5 \leq d < 1$),

4) unit roots or I(1) processes, if d = 1, and

5) explosive patterns, if d > 1.

Exogenous shocks to the series will have transitory effects as long as d is strictly below 1, whilst those effects will be permanent if $d \geq 1$, lower values of d corresponding to a faster mean-reversion process.

We estimate d by using a frequency domain version of the Whittle functions as expressed in Dahlhaus (1989), implementing a simple version of the testing approach developed in Robinson (1994) which is valid even in non-stationary contexts ($d \geq 0.5$). This method is asymptotically normally distributed but also performs well in small samples (Gil-Alana, 2000; for its functional form, see, for example, Gil-Alana and Robinson, 1997).

4. Data and Empirical Results

We use quarterly data on credit to the private non-financial sector for 43 OECD countries for the period 1951-2020. The data source is the Bank of International Settlements (BIS) Statistics Warehouse. The series used are reported at market values. The 43 OECD countries considered are the following: Turkey, Malaysia, China, Hong Kong, Spain, Australia, Russia, Belgium, Italy, Chile, India, Austria, Saudi Arabia, Hungary, Japan, Norway, United States, Netherlands, Thailand, Canada, Korea, Argentina, New Zealand, Ireland, Singapore, France, Indonesia, Sweden, Luxembourg, Poland, Denmark, Israel, Brazil, Switzerland, Colombia, Mexico, Finland, Greece, Czech Republic, Portugal, United Kingdom, South Africa and Germany.

Table 1 specifies the sample period for each country. More than 100 observations are available in most cases, the only exceptions being Brazil (97 observations), Colombia (94 observations) and Luxembourg (85 observations).

[Tables 1 and 2 about here]

Table 2 reports some descriptive statistics. In 24 countries the mean is above 100 per cent. It is noteworthy that this group of highly indebted countries includes none from Latin America; China, Hong Kong, Korea Singapore and Japan are the only Asian economies with such debt levels; most of the European, North American and Oceanian countries exceed the 100% mark.

The estimated model is the following:

$$y(t) = \alpha + \beta t + x(t); \qquad (1 - B)^{d} x(t) = u(t), \qquad t = 1, 2, ... \qquad (2)$$

where y(t) is the observed time series, α and β are unknown coefficients on the intercept and the linear time trend, and x(t) is assumed to be I(d), with d being another parameter to be estimated. Tables 3 and 4 report the estimates of d (as well as the 95% confidence bands of the non-rejection values of d using Robinson's (1994) test) for the two cases of white noise and autocorrelated errors respectively. In the latter case, the exponential spectral model of Bloomfield (1973) is adopted; this uses the spectral density function to log-approximate the log of the spectrum of an ARMA model; it displays autocorrelations also decaying exponentially but is stationary for all range of parameters unlike the AR case.

Table 3 reports the results with white noise errors for three model specifications: i) no deterministic terms, ii) an intercept, and iii) an intercept and a linear time trend. We follow a general to specific approach, starting with the specification including both regressors and sequentially dropping any insignificant coefficients to select the best specification. The time trend is found to be significant in 13 out of the 43 countries examined, namely Austria, Belgium, Canada, Switzerland, China, Germany, France, Hong Kong, India, Netherlands, New Zealand, Turkey and the US. Concerning the order of integration of the series, the lowest estimate of d is found in the case of Argentina, with a value of d of about 0.58; the correspondence confidence band does not include the value of 1, which implies that the series is mean-reverting and shocks have transitory effects. By contrast, for all the other countries the confidence band includes 1 (even in the few cases, i.e. Austria and India, when the point estimate is below 1), and therefore shocks have permanent effects.

[Tables 3 and 4 about here]

Table 4 focuses on the case of autocorrelated errors. The estimates of d are generally slightly smaller, but the same general conclusions are reached; in particular, Argentina is again the only country for which evidence of mean reversion is found, the estimated value of d being equal to 0.31. The I(1) hypothesis cannot be rejected for 13 countries (South Africa, Indonesia, Russia, Luxembourg, Brazil, China, Hong Kong, Chile, Ireland, Turkey, Cech Republic, Israel and Finland); for the remaining 39 countries the estimates of d are significantly higher than 1. Table 5 shows a summary of the results.

[Table 5 about here]

In brief, mean reversion is only found in the case of Argentina, regardless of the assumption made about the behaviour of the errors; for four countries (Turkey, Ireland, Brazil and Indonesia) the unit root null hypothesis cannot be rejected in either case; finally, for another 27 countries d is statistically higher than 1 in both cases considered. On the whole, the results are robust to the specification adopted for the error term.

To make the findings for different countries more directly comparable we also re-estimate the model over the longest span of data available for all countries, namely starting in 1999Q1 (the start date for the Luxembourg series, the shortest one); these results are displayed in Table A1 and A2 in the Appendix for the two cases of white noise and autocorrelated errors respectively. As before, all the estimated values of d are equal to or higher than 1 except for Argentina, for which mean reversion is found with autocorrelated errors.

5. Conclusions

This paper investigates the degree of persistence of the private debt-to-GDP ratio in 43 OECE countries by estimating the fractional integration parameter of each series. Almost all of them are found to be highly persistent, with orders of integration around or above 1. The only exception is Argentina, where the series appears to be mean-reverting. This reflects the relatively unique experience of this country, who underwent an economic depression from 1998 to 2002, which was followed by a significant episode of deleveraging between 2002 and 2008 (one of the 45 main such episodes since 1930 identified by the McKinsey Global Institute).

On the whole the results highlight the key importance of macroprudential policy as one of the pillars of macro policy. They suggest long-lived effects of shocks to the private debt-to-GDP ratio which require appropriate policy actions. In the specific case of the GFC credit rationing was typically accompanied by increased collateralization with significant and adverse lasting effects on the deleveraging process and economic growth. This called for a clear focus of central banks on the stability of the financial system. Prompt measures aimed at attenuating the deleveraging process and reducing the severity of the credit crunch would have been extremely beneficial and mitigated the effects of the GFC on the real sector. This is an important policy lesson to be learned to tackle future crises more effectively.

The analysis carried out in this paper can be extended in several ways. First, the presence of structural breaks such as the GFC can be examined using various methods including endogenous/exogenous break tests, rolling and/or recursive methods, sub-sample estimation. Non-linearities can also be analysed using approaches as the one proposed in Cuestas and Gil-Alana (2016) and based on Chebyshev polynomials in time. Further work can be done distinguishing between private debt held by households and by non-financial corporations (NFCs) respectively; this is particularly interesting given the crucial role played by household leverage in bringing about the GFC - according to Mian and Sufi (2010), while the total debt to income ratio increased by 0.8%, total mortgage debt grew by 34% from 2002 to 2006.

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Table 1: Set of countries and sample periods

Country	Abbrevation	Starting year	Ending year	N. of obs.
Argentina	AR	1984Q4	2020Q1	142
Austria	AT	1960Q4	2020Q1	238
Australia	AU	1960Q2	2020Q1	240
Belgium	BE	1970Q4	2020Q1	190
Brazil	BR	1996Q1	2020Q1	97
Canada	CA	1955Q4	2020Q1	258
Switzerland	CH	1960Q4	2020Q1	238
Chile	CL	1983Q1	2020Q1	149
China	CN	1985Q4	2020Q1	138
Colombia	CO	1996Q4	2020Q1	94
Czech Republic	CZ	1993Q1	2020Q1	109
Germany	DE	1960Q4	2020Q1	238
Denmark	DK	1966Q4	2020Q1	214
Spain	ES	1970Q1	2020Q1	201
Finland	FI	1970Q4	2020Q1	198
France	FR	1969Q4	2020Q1	202
United Kingdom	GB	1963Q1	2020Q1	229
Greece	GR	1970Q4	2020Q1	198
Hong Kong	HK	1978Q4	2020Q1	166
Hungary	HU	1970Q4	2020Q1	198
Indonesia	ID	1976Q1	2020Q1	177
Ireland	IE	1971Q2	2020Q1	196
Israel	IL	1990Q4	2020Q1	118
India	IN	1951Q2	2020Q1	276
Italy	IT	1960Q4	2020Q1	238
Japan	JP	1964Q4	2020Q1	222
Korea	KR	1962Q4	2020Q1	230
Luxembourg	LU	1999Q1	2020Q1	85
Mexico	MX	1980Q4	2020Q1	158
Malasya	MY	1964Q2	2020Q1	224
Netherlands	NL	1961Q1	2020Q1	237
Norway	NO	1960Q4	2020Q1	238
New Zeland	NZ	1960Q4	2020Q1	238
Poland	PL	1992Q1	2020Q1	113
Portugal	PT	1960Q4	2020Q1	238
Russia	RU	1995Q2	2020Q1	100
Saudi Arabia	SA	1993Q1	2020Q1	109
Sweden	SE	1961Q1	2020Q1	237
Singapore	SG	1970Q4	2020Q1	198
Thailand	TH	1970Q4	2020Q1	198
Turkey	TR	1986Q1	2020Q1	137
United States	US	1952Q1	2020Q1	273
South Africa	ZA	1965Q1	2020Q1	221

Table 2: Descriptive statistics

Country	Mean	Std. Dev.	Max. value	Min. Value
AR	29.5	11.8	91.1	9.4
AT	94.9	38.2	147.6	29.9
AU	115.9	49.6	202.3	53.0
BE	131.2	50.5	229.7	77.3
BR	57.1	10.6	78.3	44.0
CA	128.8	40.6	220.6	71.7
CH	173.2	40.2	257.5	114.2
CL	95.2	28.5	162.3	52.9
CN	120.5	44.7	216.2	64.2
CO	51.1	8.0	65.6	39.2
CZ	79.6	10.8	93.1	59.1
DE	101.5	18.7	132.6	58.5
DK	161.2	48.5	254.6	103.7
ES	117.6	53.6	226.8	67.0
FI	125.9	34.8	193.4	79.9
FR	137.9	32.5	218.0	93.8
GB	111.6	48.4	193.8	52.7
GR	66.6	35.0	133.6	34.3
HK	177.8	54.2	321.8	83.8
HU	70.3	25.7	136.9	35.4
ID	36.3	16.0	129.5	18.0
IE	146.8	93.0	400.8	66.1
IL	109.8	14.4	132.1	77.2
IN	29.0	16.5	62.0	10.8
IT	81.1	22.9	126.8	51.5
JP	163.8	29.0	218.2	113.2
KR	111.7	51.8	201.0	19.6
LU	303.7	101.3	424.4	126.5
MX	32.4	7.7	51.1	19.1
MY	89.2	47.5	167.1	10.9
NL	162.5	79.3	294.3	39.3
NO	160.6	43.5	257.2	110.3
NZ	102.5	59.7	201.3	26.1
PL	54.2	22.3	86.3	20.4
PT	127.5	48.8	231.6	59.3
RU	55.9	29.4	103.9	14.9
SA	42.1	11.3	68.6	25.5
SE	148.1	48.1	256.0	99.4
SG	116.3	27.0	178.1	66.1
TH	89.0	38.5	181.9	26.9
TR	39.2	24.7	95.5	14.8
US	112.9	30.8	170.0	53.6
ZA	59.5	8.2	79.0	47.1

Table 3: Estimated values of d with white noise errors

Country	No regressors	An intercept	An intercept and a linear time trend
AR	0.73 (0.61, 0.89)	**0.59 (0.48, 0.79)**	0.58 (0.45, 0.79)
AT	0.95 (0.85, 1.07)	0.97 (0.91, 1.05)	**0.97 (0.91, 1.04)**
AU	1.05 (0.96, 1.17)	**1.35 (1.27, 1.45)**	1.35 (1.27, 1.45)
BE	0.98 (0.89, 1.10)	1.09 (1.01, 1.19)	**1.09 (1.01, 1.20)**
BR	0.94 (0.79, 1.14)	**1.09 (0.97, 1.26)**	1.09 (0.96, 1.27)
CA	1.03 (0.95, 1.14)	1.18 (1.10, 1.28)	**1.19 (1.10, 1.29)**
CH	1.01 (0.93, 1.12)	1.14 (1.06, 1.23)	**1.14 (1.06, 1.23)**
CL	1.04 (0.94, 1.20)	**1.24 (1.12, 1.40)**	1.24 (1.13, 1.40)
CN	1.05 (0.97, 1.26)	1.17 (1.05, 1.35)	**1.17 (1.05, 1.34)**
CO	1.05 (0.91, 1.23)	**1.49 (1.35, 1.68)**	1.48 (1.35, 1.68)
CZ	0.96 (0.83, 1.13)	**1.14 (1.04, 1.30)**	1.14 (1.04, 1.29)
DE	1.03 (0.95, 1.13)	1.16 (1.10, 1.24)	**1.15 (1.09, 1.23)**
DK	1.00 (0.91, 1.11)	**1.28 (1.22, 1.36)**	1.28 (1.22, 1.37)
ES	1.11 (1.03, 1.21)	**1.38 (1.32, 1.44)**	1.37 (1.32, 1.44)
FI	1.01 (0.91, 1.14)	**1.40 (1.28, 1.56)**	1.40 (1.28, 1.57)
FR	1.01 (0.92, 1.12)	1.12 (1.06, 1.21)	**1.13 (1.07, 1.21)**
GB	1.02 (0.94, 1.13)	**1.16 (1.10, 1.23)**	1.16 (1.10, 1.23)
GR	1.11 (1.03, 1.24)	**1.30 (1.24, 1.37)**	1.30 (1.24, 1.37)
HK	1.10 (1.00, 1.25)	1.14 (1.04, 1.29)	**1.14 (1.04, 1.29)**
HU	1.08 (1.00, 1.19)	**1.10 (1.04, 1.19)**	1.10 (1.04, 1.19)
ID	1.12 (0.98, 1.31)	**1.14 (1.00, 1.33)**	1.14 (1.00, 1.33)
IE	1.00 (0.91, 1.11)	**1.06 (0.99, 1.16)**	1.06 (0.99, 1.16)
IL	0.97 (0.86, 1.13)	**1.15 (1.05, 1.30)**	1.15 (1.04, 1.30)
IN	0.96 (0.90, 1.03)	0.97 (0.93, 1.03)	**0.97 (0.92, 1.04)**
IT	1.03 (0.96, 1.13)	**1.09 (1.05, 1.15)**	1.09 (1.05, 1.15)
JP	1.04 (0.96, 1.14)	**1.30 (1.23, 1.41)**	1.30 (1.22, 1.41)
KR	1.22 (1.13, 1.33)	**1.30 (1.21, 1.40)**	1.29 (1.20, 1.40)
LU	1.12 (0.91, 1.41)	**1.71 (1.43, 2.06)**	1.70 (1.42, 2.06)
MX	1.11 (1.00, 1.25)	**1.24 (1.15, 1.37)**	1.24 (1.15, 1.37)
MY	1.38 (1.29, 1.50)	**1.43 (1.33, 1.55)**	1.43 (1.33, 1.55)
NL	1.04 (0.95, 1.16)	1.23 (1.15, 1.32)	**1.23 (1.15, 1.31)**
NO	1.07 (0.97, 1.19)	**1.34 (1.25, 1.47)**	1.34 (1.25, 1.46)
NZ	1.07 (0.96, 1.18)	1.09 (1.03, 1.17)	**1.09 (1.03, 1.17)**
PL	0.97 (0.80, 1.17)	**1.35 (1.22, 1.53)**	1.35 (1.22, 1.53)
PT	1.10 (1.02, 1.19)	**1.32 (1.26, 1.39)**	1.32 (1.26, 1.39)
RU	1.04 (0.88, 1.28)	**1.15 (1.01, 1.35)**	1.15 (1.01, 1.35)
SA	1.16 (1.00, 1.36)	**1.39 (1.19, 1.64)**	1.39 (1.19, 1.64)
SE	1.02 (0.94, 1.12)	**1.28 (1.21, 1.38)**	1.28 (1.21, 1.38)
SG	1.08 (0.99, 1.22)	**1.21 (1.12, 1.34)**	1.21 (1.11, 1.34)
TH	1.24 (1.17, 1.32)	**1.30 (1.23, 1.41)**	1.30 (1.23, 1.41)
TR	1.04 (0.94, 1.19)	1.04 (0.96, 1.16)	**1.04 (0.95, 1.16)**
US	1.07 (0.99, 1.17)	1.32 (1.26, 1.40)	**1.31 (1.25, 1.37)**
ZA	1.01 (0.91, 1.31)	**1.19 (1.10, 1.31)**	1.20 (1.10, 1.31)

The values in parenthesis are the 95% confidence bands of the values of d. In bold, the selected specification on the basis of the statistical significance of the deterministic terms.

Table 4: Estimated values of d with autocorrelated errors

Country	No regressors	An intercept	An intercept and a linear time trend
AR	0.59 (0.44, 0.77)	0.38 (0.27, 0.54)	**0.31 (0.17, 0.50)**
AT	0.89 (0.70, 1.14)	1.17 (1.06, 1.34)	**1.17 (1.05, 1.31)**
AU	0.98 (0.82, 1.16)	**1.45 (1.29, 1.68)**	1.45 (1.30, 1.66)
BE	0.93 (0.80, 1.16)	**1.17 (1.02, 1.44)**	1.19 (1.02, 1.44)
BR	0.79 (0.55, 1.13)	**1.06 (0.86, 1.40)**	1.05 (0.83, 1.41)
CA	0.98 (0.85, 1.16)	1.21 (1.06, 1.47)	**1.24 (1.08, 1.47)**
CH	0.98 (0.84, 1.17)	**1.23 (1.09, 1.44)**	1.24 (1.08, 1.44)
CL	0.99 (0.84, 1.26)	1.07 (0.91, 1.32)	**1.07 (0.90, 1.32)**
CN	0.94 (0.76, 1.20)	1.04 (0.90, 1.33)	**1.06 (0.87, 1.34)**
CO	0.97 (0.72, 1.30)	**1.59 (1.29, 2.16)**	1.65 (1.30, 2.04)
CZ	0.86 (0.66, 1.14)	**1.09 (0.93, 1.30)**	1.09 (0.93, 1.29)
DE	1.04 (0.91, 1.22)	**1.40 (1.27, 1.61)**	1.37 (1.25, 1.58)
DK	0.98 (0.83, 1.18)	**1.50 (1.35, 1.70)**	1.51 (1.36, 1.72)
ES	1.15 (1.02, 1.34)	**1.74 (1.62, 1.92)**	1.75 (1.62, 1.91)
FI	0.89 (0.74, 1.12)	**1.15 (0.99, 1.35)**	1.15 (0.99, 1.35)
FR	1.00 (0.87, 1.18)	1.28 (1.16, 1.49)	**1.30 (1.18, 1.48)**
GB	1.02 (0.89, 1.21)	**1.32 (1.22, 1.46)**	1.32 (1.22, 1.48)
GR	1.15 (1.02, 1.35)	**1.56 (1.44, 1.75)**	1.55 (1.43, 1.73)
HK	1.01 (0.86, 1.21)	1.05 (0.91, 1.32)	**1.06 (0.90, 1.31)**
HU	1.09 (0.97, 1.27)	**1.21 (1.10, 1.35)**	1.21 (1.10, 1.35)
ID	0.78 (0.63, 1.02)	**0.77 (0.60, 1.02)**	0.76 (0.62, 1.02)
IE	0.95 (0.84, 1.11)	**1.07 (0.95, 1.23)**	1.07 (0.95, 1.23)
IL	0.90 (0.72, 1.16)	**1.11 (0.97, 1.32)**	1.10 (0.97, 1.30)
IN	1.06 (0.96, 1.21)	**1.20 (1.11, 1.32)**	1.20 (1.11, 1.32)
IT	1.10 (0.96, 1.26)	**1.49 (1.38, 1.64)**	1.48 (1.38, 1.63)
JP	1.03 (0.91, 1.25)	**1.20 (1.09, 1.32)**	1.18 (1.09, 1.31)
KR	1.24 (1.03, 1.50)	**1.41 (1.19, 1.68)**	1.40 (1.18, 1.68)
LU	0.51 (0.40, 1.10)	1.04 (0.79, 1.66)	**1.04 (0.72, 1.66)**
MX	1.04 (0.86, 1.31)	**1.43 (1.19, 1.80)**	1.43 (1.19, 1.81)
MY	1.35 (1.16, 1.62)	**1.37 (1.17, 1.62)**	1.37 (1.17, 1.62)
NL	0.97 (0.79, 1.18)	**1.32 (1.19, 1.50)**	1.33 (1.19, 1.49)
NO	0.98 (0.82, 1.19)	**1.31 (1.08, 1.64)**	1.31 (1.09, 1.61)
NZ	1.10 (0.95, 1.28)	**1.31 (1.17, 1.48)**	1.32 (1.18, 1.49)
PL	0.67 (0.54, 1.02)	**1.18 (1.01, 1.43)**	1.19 (1.01, 1.43)
PT	1.13 (1.00, 1.28)	**1.50 (1.36, 1.66)**	1.50 (1.37, 1.67)
RU	0.73 (0.61, 1.01)	0.91 (0.78, 1.20)	**0.88 (0.58, 1.22)**
SA	0.94 (0.61, 1.39)	0.84 (0.60, 1.34)	**0.83 (0.47, 1.35)**
SE	1.02 (0.91, 1.20)	**1.38 (1.22, 1.63)**	1.39 (1.21, 1.63)
SG	1.09 (0.90, 1.33)	**1.20 (1.01, 1.78)**	1.19 (1.01, 1.46)
TH	1.35 (1.20, 1.55)	**1.51 (1.30, 1.72)**	1.50 (1.29, 1.71)
TR	0.97 (0.85, 1.17)	1.08 (0.96, 1.27)	**1.08 (0.95, 1.29)**
US	1.03 (0.89, 1.22)	**1.82 (1.64, 2.12)**	1.74 (1.58, 2.00)
ZA	0.90 (0.77, 1.11)	**1.21 (1.01, 1.47)**	1.21 (1.01, 1.47)

The values in parenthesis are the 95% confidence bands of the values of d. In bold, the selected specification on the basis of the statistical significance of the deterministic terms.

Table 5: Summary table

No autocorrelation			Autocorrelation		
Mean reversion	Unit roots	Explosive	Mean reversion	Unit roots	Explosive
d < 1	d = 1	d > 1	d < 1	d = 1	d > 1
AR (0.59)	AT (0.97)	BE (1.09)	AR (0.31)	ID (0.77)	AT (1.17)
	IN (0.97)	IT (1.09)		SA (0.83)	BE (1.17)
	TR (1.04)	NZ (1.09)		RU (0.88)	PL (1.18)
	IE (1.06)	HU (1.10)		LU (1.04)	IN (1.20)
	BR (1.09)	FR (1.13)		BR (1.06)	SG (1.20)
	ID (1.14)	CH (1.14)		CN (1.06)	JP (1.20)
		CZ (1.14)		HK (1.06)	HU (1.21)
		HK (1.14)		CL (1.07)	ZA (1.21)
		DE (1.15)		IE (1.07)	CH (1.23)
		RU (1.15)		TR (1.08)	CA (1.24)
		IL (1.15)		CZ (1.09)	FR (1.30)
		GB (1.16)		IL (1.11)	NO (1.31)
		CN (1.17)		FI (1.15)	NZ (1.31)
		CA (1.19)			GB (1.32)
		ZA (1.19)			NL (1.32)
		SG (1.21)			MY (1.37)
		NL (1.23)			SE (1.38)
		CL (1.24)			MX (1.43)
		MX (1.24)			AU (1.45)
		DK (1.28)			IT (1.49)
		SE (1.28)			PT (1.50)
		GR (1.30)			TH (1.51)
		JP (1.30)			GR (1.56)
		KR (1.30)			DE (1.40)
		TH (1.30)			KR (1.41)
		US (1.31)			DK (1.50)
		PT (1.32)			CO (1.59)
		NO (1.34)			ES (1.74)
		AU (1.35)			US (1.82)
		PL (1.35)			
		ES (1.38)			
		SA (1.39)			
		FI (1.40)			
		MY (1.43)			
		CO (1.49)			
		LU (1.71)			

APPENDIX

Table A1: Estimated values of d with white noise errors, 1999Q1-2020Q1

Country	No regressors		An intercept		An intercept and a linear time trend	
AR	1.02	(0.86, 1.28)	**1.16**	**(0.89, 1.60)**	1.17	(0.89, 1.60)
AT	0.99	(0.85, 1.07)	1.00	(0.86, 1.19)	**1.00**	**(0.89, 1.16)**
AU	0.97	(0.83, 1.16)	**1.42**	**(1.30, 1.59)**	1.40	(1.28, 1.57)
BE	0.97	(0.82, 1.16)	1.06	(0.90, 1.26)	**1.05**	**(0.90, 1.25)**
BR	0.93	(0.78, 1.12)	**1.05**	**(0.93, 1.22)**	1.05	(0.93, 1.22)
CA	0.95	(0.80, 1.15)	1.16	(1.03, 1.36)	**1.17**	**(1.03, 1.36)**
CH	0.97	(0.83, 1.18)	1.10	(0.99, 1.27)	**1.11**	**(0.99, 1.29)**
CL	1.08	(0.94, 1.28)	**1.27**	**(1.12, 1.48)**	1.28	(1.13, 1.48)
CN	1.05	(0.90, 1.28)	1.21	(1.03, 1.49)	**1.21**	**(1.04, 1.46)**
CO	0.97	(0.82, 1.20)	**1.44**	**(1.31, 1.63)**	1.43	(1.31, 1.63)
CZ	0.91	(0.76, 1.13)	**1.17**	**(1.07, 1.33)**	1.17	(1.07, 1.32)
DE	1.00	(0.88, 1.19)	**1.43**	**(1.30, 1.63)**	1.42	(1.29, 1.60)
DK	0.95	(0.80, 1.14)	**1.30**	**(1.21, 1.43)**	1.29	(1.20, 1.42)
ES	1.09	(0.97, 1.26)	1.48	(1.40, 1.59)	**1.43**	**(1.37, 1.53)**
FI	0.97	(0.81, 1.20)	1.16	(0.97, 1.48)	**1.16**	**(0.97, 1.47)**
FR	0.98	(0.84, 1.18)	1.19	(1.02, 1.47)	**1.20**	**(1.03, 1.42)**
GB	0.99	(0.87, 1.18)	**1.22**	**(1.12, 1.35)**	1.20	(1.12, 1.32)
GR	1.03	(0.91, 1.20)	**1.37**	**(1.28, 1.48)**	1.34	(1.26, 1.45)
HK	0.96	(0.80, 1.19)	1.08	(0.97, 1.27)	**1.09**	**(0.96, 1.28)**
HU	1.05	(0.92, 1.22)	**1.09**	**(1.00, 1.21)**	1.08	(1.00, 1.21)
ID	0.65	(0.52, 0.83)	**1.00**	**(0.86, 1.17)**	1.00	(0.87, 1.17)
IE	0.97	(0.84, 1.17)	**1.04**	**(0.93, 1.20)**	1.04	(0.93, 1.20)
IL	0.97	(0.85, 1.16)	**1.20**	**(1.05, 1.43)**	1.20	(1.05, 1.42)
IN	0.93	(0.79, 1.10)	0.94	(0.86, 1.04)	**0.94**	**(0.87, 1.04)**
IT	1.01	(0.87, 1.21)	1.29	(1.21, 1.41)	**1.27**	**(1.19, 1.36)**
JP	0.97	(0.83, 1.16)	**1.27**	**(1.14, 1.48)**	1.26	(1.13, 1.46)
KR	0.92	(0.76, 1.12)	**1.43**	**(1.29, 1.61)**	1.42	(1.29, 1.59)
LU	1.12	(0.91, 1.41)	**1.72**	**(1.43, 2.06)**	1.71	(1.42, 2.05)
MX	0.96	(0.79, 1.23)	**1.07**	**(0.97, 1.22)**	1.07	(0.97, 1.23)
MY	0.93	(0.80, 1.13)	**1.40**	**(1.23, 1.63)**	1.37	(1.22, 1.60)
NL	0.95	(0.80, 1.15)	**1.27**	**(1.16, 1.43)**	1.27	(1.16, 1.42)
NO	0.98	(0.81, 1.20)	**1.30**	**(1.14, 1.53)**	1.30	(1.14, 1.52)
NZ	0.97	(0.84, 1.16)	**1.38**	**(1.27, 1.55)**	1.37	(1.26, 1.54)
PL	1.00	(0.84, 1.23)	**1.30**	**(1.15, 1.54)**	1.29	(1.14, 1.52)
PT	1.03	(0.93, 1.19)	1.57	(1.46, 1.76)	**1.51**	**(1.41, 1.66)**
RU	0.93	(0.75, 1.17)	**1.14**	**(1.02, 1.33)**	1.15	(1.02, 1.33)
SA	1.01	(0.84, 1.24)	**1.39**	**(1.19, 1.65)**	1.39	(1.19, 1.66)
SE	0.95	(0.80, 1.14)	1.17	(1.05, 1.33)	**1.17**	**(1.05, 1.32)**
SG	0.98	(0.84, 1.18)	**1.24**	**(1.09, 1.44)**	1.25	(1.11, 1.45)
TH	0.90	(0.75, 1.10)	1.36	(1.26, 1.49)	**1.32**	**(1.23, 1.43)**
TR	0.93	(0.77, 1.17)	1.02	(0.92, 1.17)	**1.02**	**(0.90, 1.19)**
US	1.00	(0.86, 1.19)	**1.53**	**(1.41, 1.70)**	1.48	(1.38, 1.62)
ZA	0.96	(0.82, 1.18)	**1.14**	**(1.02, 1.29)**	1.14	(1.02, 1.29)

The values in parenthesis are the 95% confidence bands of the values of d. In bold, the selected specification on the basis of the statistical significance of the deterministic terms.

Table A2: Estimated values of d with autocorrelated errors, 1999Q1-2020Q1

Country	No regressors	An intercept	An intercept and a linear time trend
AR	0.73 (0.53, 1.01)	0.47 (0.33, 0.69)	**0.39 (0.17, 0.71)**
AT	0.92 (0.69, 1.28)	1.00 (0.66, 1.32)	**1.02 (0.81, 1.26)**
AU	0.89 (0.64, 1.23)	**1.58 (1.27, 2.10)**	1.51 (1.25, 2.13)
BE	0.87 (0.50, 1.24)	1.08 (0.75, 1.64)	**1.05 (0.70, 1.58)**
BR	0.85 (0.58, 1.28)	**1.11 (0.89, 1.51)**	1.11 (0.86, 1.51)
CA	0.82 (0.55, 1.16)	1.09 (0.90, 1.58)	**1.11 (0.82, 1.58)**
CH	0.86 (0.62, 1.20)	1.11 (0.96, 1.41)	**1.14 (0.94, 1.50)**
CL	0.98 (0.74, 1.33)	**1.23 (0.98, 1.65)**	1.24 (0.96, 1.63)
CN	0.85 (0.59, 1.25)	1.01 (0.84, 1.52)	**1.01 (0.78, 1.47)**
CO	0.77 (0.49, 1.15)	**1.48 (1.28, 1.94)**	1.49 (1.28, 1.96)
CZ	0.75 (0.46, 1.14)	**1.19 (1.01, 1.43)**	1.20 (1.01, 1.41)
DE	0.96 (0.73, 1.27)	**1.45 (1.20, 1.86)**	1.45 (1.20, 1.83)
DK	0.87 (0.59, 1.19)	**1.46 (1.28, 1.72)**	1.43 (1.26, 1.69)
ES	1.06 (0.86, 1.31)	**1.77 (1.61, 2.06)**	1.67 (1.54, 1.89)
FI	0.73 (0.23, 1.14)	0.86 (0.75, 1.15)	**0.81 (0.56, 1.15)**
FR	0.88 (0.60, 1.22)	1.11 (0.94, 1.52)	**1.11 (0.86, 1.53)**
GB	0.95 (0.73, 1.24)	**1.38 (1.19, 1.64)**	1.34 (1.18, 1.52)
GR	1.01 (0.77, 1.33)	**1.64 (1.46, 2.09)**	1.59 (1.41, 2.10)
HK	0.76 (0.52, 1.18)	0.94 (0.82, 1.13)	**0.91 (0.72, 1.16)**
HU	1.02 (0.82, 1.28)	**1.20 (1.06, 1.39)**	1.20 (1.06, 1.37)
ID	0.71 (0.45, 1.16)	**1.29 (1.09, 1.60)**	1.27 (1.08, 1.93)
IE	0.86 (0.51, 1.10)	**1.02 (0.84, 1.24)**	1.02 (0.83, 1.25)
IL	0.95 (0.61, 1.27)	**1.02 (0.82, 1.30)**	1.02 (0.83, 1.28)
IN	0.93 (0.65, 1.30)	**1.35 (1.17, 1.60)**	1.30 (1.14, 1.66)
IT	0.92 (0.65, 1.27)	**1.54 (1.40, 1.77)**	1.48 (1.35, 1.64)
JP	0.90 (0.66, 1.25)	1.02 (0.79, 1.29)	**1.00 (0.82, 1.26)**
KR	0.81 (0.50, 1.17)	**1.58 (1.14, 2.41)**	1.47 (1.15, 2.53)
LU	0.51 (0.40, 1.13)	1.04 (0.79, 1.65)	**1.03 (0.72, 1.64)**
MX	0.63 (0.39, 1.17)	1.02 (0.89, 1.19)	**1.01 (0.83, 1.20)**
MY	0.83 (0.56, 1.14)	**1.17 (0.95, 1.58)**	1.16 (0.97, 1.46)
NL	0.81 (0.47, 1.19)	**1.34 (1.13, 1.63)**	1.34 (1.13, 1.62)
NO	0.77 (0.28, 1.20)	1.15 (0.84, 1.88)	**1.11 (0.79, 1.75)**
NZ	0.93 (0.68, 1.25)	**1.41 (1.19, 1.74)**	1.39 (1.18, 1.75)
PL	0.74 (0.40, 1.18)	1.09 (0.86, 1.41)	**1.08 (0.83, 1.40)**
PT	0.96 (0.73, 1.27)	1.56 (1.39, 1.84)	**1.48 (1.35, 1.69)**
RU	0.63 (0.52, 1.05)	1.01 (0.82, 1.37)	**1.01 (0.62, 1.37)**
SA	0.79 (0.40, 1.29)	0.92 (0.64, 1.42)	**0.94 (0.54, 1.42)**
SE	1.86 (0.55, 1.23)	**1.41 (1.09, 1.86)**	1.41 (1.08, 1.86)
SG	0.90 (0.66, 1.29)	**1.17 (0.92, 1.62)**	1.16 (0.93, 1.62)
TH	0.71 (1.47, 1.08)	1.55 (1.32, 1.85)	**1.47 (1.30, 1.88)**
TR	0.73 (0.61, 1.04)	1.04 (0.90, 1.29)	**1.03 (0.84, 1.30)**
US	0.93 (0.70, 1.26)	**1.87 (1.58, 2.71)**	1.77 (1.51, 2.73)
ZA	0.81 (0.55, 1.17)	**1.30 (1.04, 1.62)**	1.30 (1.04, 1.62)

The values in parenthesis are the 95% confidence bands of the values of d. In bold, the selected specification on the basis of the statistical significance of the deterministic terms.