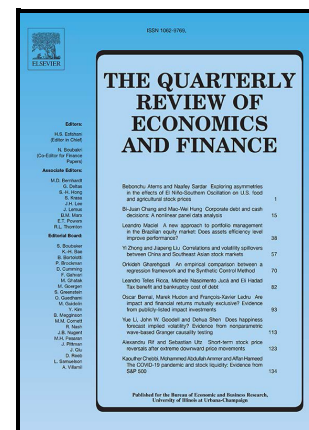


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**THE COVID-19 PANDEMIC AND THE DEGREE OF PERSISTENCE
OF US STOCK PRICES AND BOND YIELDS**

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Revised, April 2022

Abstract

This paper analyses the possible effects of the Covid-19 pandemic on the degree of persistence of US monthly stock prices and bond yields using fractional integration techniques. The model is estimated first over the period January 1966-December 2020 and then a recursive approach is taken to examine whether or not persistence has changed during the following pandemic period (up to February 2021). We find that the unit root hypothesis cannot be rejected for stock prices while for bond yields the results differ depending on the maturity date and the specification of the error term. In general, bond yields appear to be more persistent, although there is evidence of mean reversion in case of 1-year yields under the assumption of autocorrelated errors. The recursive analysis shows no impact of the Covid-19 pandemic on the persistence of stock prices, whilst there is an increase in the case of both 10- and 1- year bond yields but not of their spread.

Keywords: Stock market prices; US bonds; persistence; fractional integration; Covid-19

JEL classification: C22, G10

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1. Introduction

The Covid-19 pandemic is a global health crisis that has required the introduction of lockdowns and other restrictive measures aimed at containing the spread of the Coronavirus with a devastating impact on the world economy. Although previous pandemics such as the SARS (Severe Acute Respiratory Syndrome) outbreak had also had economic consequences (see, e.g., Chen et al., 2007, 2009) the current crisis has had unprecedented effects, being a combination of both supply and demand shocks that have required prompt and extensive policy measures (see Caporale and Cerrato, 2020). In addition to the real economy, financial markets have also been hit by the great degree of uncertainty generated by this crisis (see Baker et al., 2020). There exist already a few studies providing some preliminary evidence of their response to the Covid-19 outbreak, which has generated concerns about future economic prospects (see, e.g., Ramelli and Wagner, 2020 for the impact on various stock markets and Al-Awadhi et al., 2020, specifically for the Chinese case).

The present paper focuses on the US case and analyses the possible effects of the Covid-19 pandemic on the degree of persistence of both US monthly stock prices and bond yields. The adopted framework is based on the concept of fractional integration and is more general and flexible than the standard one which is characterised by the classical dichotomy between stationary $I(0)$ and non-stationary $I(1)$ series since it allows the difference parameter to take fractional as well as integer values. The model is estimated first over the period from January 1966 to December 2019 to obtain a measure of the degree of persistence of the series of interest prior to the Covid-19 outbreak. Then a recursive approach is taken to examine whether or not this has changed during the pandemic period (up to February 2021). The analysis carried out in the paper provides evidence on the extent to which stock prices and bond yields are

predictable and thus on whether the Efficient Market Hypothesis (EMH) holds, in which case prices should fully reflect available information and therefore should follow a random walk – in particular, the fractional integration methods used here enable us to shed light on the stochastic properties of the series of interest, on whether or not they are mean reverting, and on the speed of the dynamic adjustment process, thereby obtaining evidence on the degree of efficiency of US stock and bond markets and also on whether this has changed as a result of the Covid-19 pandemic.

In brief, the aim of this study is twofold, namely: (i) to analyse the dynamics of both types of series using an approach that allows the estimation of possibly fractional orders of integration providing a measure of persistence; (ii) to examine whether the degree of persistence has been affected by the Covid-19 pandemic. In particular, the recursive estimates provide information on whether an exogenous shock such as the Covid-19 pandemic has had any effect on the degree of persistence of the series of interest, and thus on the speed of the dynamic adjustment towards the long-run equilibrium.

The layout of the paper is as follows. Section 2 briefly reviews the relevant literature on US financial markets. Section 3 outlines the methodology. Section 4 describes the data and presents the empirical results. Section 5 offers some concluding remarks.

2. Literature Review

The degree of persistence of US stock prices and bond yields has already been analysed in various studies; however, unlike the present one, most of them do not include the entire Covid-19 period, during which the stochastic properties of these series might have changed. For example, Caporale et al. (2022) examined the stochastic behaviour of

US monthly 10-year government bond yields using two different series, namely one from Bloomberg including end-of-the-month values over the period January 1962-August 2020, and another from the ECB reporting average monthly values over the period January 1900-August 2020. They estimated a fractional integration model suitable to capture both persistence and non-linearities. Their results show that both series are highly persistent and exhibit non-linearities, whilst there is evidence of the presence of structural breaks. Abakah and Gil-Alana (2022) also analysed the persistence of the US Treasury bond yields from 1946 to 2019 using fractional integration methods. They found that the degree of integration of the series (their persistence) is inversely related to the maturity of the bonds. Finally, Demirel and Unal (2020) analysed 203 local bonds in the emerging markets of Indonesia, Brazil, India, South Africa, Mexico, and Turkey from a portfolio risk perspective; specifically, they estimated fractional models for risk evaluation.

As for share prices, Adekoya (2021) analysed their dynamic behaviour in the OECD countries using a fractional integration framework allowing for nonlinear deterministic trends modelled as Chebyshev polynomials. They showed the importance of specifying correctly the autocorrelation structure and found evidence of nonlinear behaviour in the persistence of the series, especially in Belgium, Japan and Hungary, whose markets appear to have become less efficient over time. Bala and Gupta (2021) examined the long memory properties of stock liquidity and returns in the Indian equity market using data from January 1997 to December 2019 and found evidence of time-varying degree of persistence in the series of interest; moreover, the liquidity series for the Nifty-100, Nifty-200 and Nifty MidCap-50 exhibit long memory.

Caporale et al. (2020) studied persistence, structural breaks and non-linearities in the case of five European stock market indices, again using fractional integration

methods, over the period from January 2009 to January 2019. Their results provide no evidence of non-linearities in either prices or returns; also, the former are found to exhibit unit roots and the latter to be $I(0)$ in most cases; finally, between 2 and 4 structural breaks are found for each of the return series, and mean reversion occurs in some subsamples. Alfred and Sivarajasingham (2020) used an Autoregressive Fractionally Integrated Moving Average (ARFIMA) model to analyse the behaviour of returns for the All Share Price Index in Sri Lanka over the period from January 1985 to September 2018 and found no evidence of long memory. Finally, Balcilar et al. (2015) investigated whether the daily stock price indices from 14 emerging markets follow a random walk or a mean-reverting long-memory process; their framework for analysing persistence is more general than the $I(0)/I(1)$ paradigm and allows for multiple structural breaks at unknown dates. They found support for the random walk hypothesis for all stock markets except four for which weak evidence of mean-reverting long-memory behaviour was obtained; unit roots were found in all cases except Mexico even when structural breaks were taken into account.

The study by Štifanić et al. (2020) is one of the very few analysing the possible effects of the Covid-19 pandemic, specifically on Crude Oil price and three US stock indices: DJI, S&P 500, and NASDAQ Composite; their approach to forecasting commodity and stock prices integrates the stationary wavelet transform (SWT) and bidirectional long short-term memory (BDLSTM) networks. They concluded that the Covid-19 pandemic caused only a temporary slump in commodities and equity prices.

Other studies focus on asset price volatility. As highlighted by Dräger et al. (2020), the degree of long memory in stock market volatility can be interpreted as a measure of uncertainty: high degrees of long memory imply a low degree of uncertainty. Caporale et al. (2018) studied the degree of persistence of market fear as

measured by the VIX index from 2004 to 2016 and found that its properties vary over time: in normal periods it exhibits anti-persistence, whereas during recession persistence increases. Hiremath and Bandi (2010) obtained evidence of long memory in volatility in the case of the Indian stock market using the fractionally integrated generalized autoregressive conditional heteroscedasticity (FIGARCH) model, which is shown to capture more accurately the persistence in volatility than the conventional ARCH-GARCH models.

The same conclusions have been also reached by Christensen and Nielsen (2007) and Kasman and Torun (2007) for other markets. Martens et al. (2004) used instead a nonlinear Autoregressive Fractionally Integrated Moving Average (ARFIMA) model to analyse volatility in the S&P500 stock index, and emphasised that a high degree of uncertainty causes investors to look for shelter assets. Finally, Eickmeier et al. (2017) noted that in the US reductions in interest rates by monetary authorities usually have a smaller impact on investment and output during periods of high volatility.

Compared to the studies reviewed above, the present one focuses on the US only instead of a set of countries and uses fractional integration methods to measure the degree of persistence of the stock market indices and bond yields over a period which also includes the Covid-19 pandemic, thereby providing evidence on its possible impact.

3. Methodology

Our modelling approach is based on the concept of fractional integration and is more general than the standard framework that only allows for integer degrees of differentiation. Specifically, a time series x_t is said to be integrated of order d or $I(d)$ if it can be represented as:

$$(I - B)^d x_t = u_t, \quad t = 1, 2, \dots, \quad (1)$$

where B is the backshift operator, and u_t exhibits short-memory, is integrated of order 0 ($I(0)$) and follows a white noise or weakly autocorrelated (e.g., ARMA) process. If $d > 0$ in (1) then x_t is said to be a long-memory process since the autocorrelations decay hyperbolically, and the higher the value of d is, the slower is the rate of decay. Note that allowing d to be any real value enables one to consider a wide range of cases, including short memory ($d = 0$), stationary long memory ($0 < d < 0.5$); nonstationary mean reverting processes ($0.5 \leq d < 1$); unit roots ($d = 1$) or even explosive patterns ($d > 1$) (Reisen et al., 2003).

In our empirical analysis we also allow for a linear time trend and assume that x_t in (1) are the errors in a regression model of the form:

$$y_t = \alpha + \beta t + x_t, \quad t = 1, 2, \dots, \quad (2)$$

where y_t stands for the series of interest, x_t is the error term, and α and β are unknown parameters to be estimated, respectively a constant and the coefficient on the linear time trend. The estimation is based on the Whittle function in the frequency domain and follows a testing procedure developed by Robinson (1994) which is most appropriate in the case of nonstationary series such as those analysed in this paper. There are several advantages when using this approach. First, it is valid even in nonstationary contexts, i.e., with $d \geq 0.5$, unlike most of other procedures that require differentiation prior to the analysis in the case of nonstationary series; second, it follows asymptotically a standard $N(0,1)$ distribution, which holds independently of the inclusion of deterministic terms such as an intercept or a time trend in the model as in our case; finally, it is the most efficient method in the Pitman sense against local alternatives. In addition, as a robustness check, we also implemented other approaches such as Sowell's maximum likelihood estimation method and two semiparametric approaches (Robinson, 1995a,b)

based respectively on Whittle and log-periodogram estimation. In all cases, the results were very similar to those reported in the paper.

4. Data and Empirical Results

We examine four seasonally unadjusted US stock market indices (NYSE, NASDAQ 100, S&P500, and Dow Jones) as well as US 10-year and 1-year Treasury bond yields and their spread (measured in percentage points); the series are monthly and the sample period goes from January 1966 to January 2021, therefore the total number of observations in each case is 661. The chosen time span includes the last 8 NBER-dated recessions (NBER, 2021). The data source is Thomson Reuters Eikon. Table 1 reports some descriptive statistics for the series under examination. It can be seen that the US Dow Jones Index has the widest range and standard deviation, followed by NYSE Composite and NASDAQ 100, while S&P500 Composite is the least volatile series.

[Insert Table 1 about here]

Our objective is to analyse the possible impact of the Covid-19 pandemic on the parameter d , which is a measure of persistence, for both stock prices and bond yields; therefore, as a first step we estimate the model up to December 2019 (namely, immediately before the start of the pandemic), and then use recursive methods to investigate the evolution of d from January 2020 onwards (namely, during the pandemic). Table 2 displays the estimates of d and the corresponding 95% confidence bands in the case of stock prices for the sample period ending in December 2019; we consider three possible specifications: i) no deterministic terms, ii) an intercept only, and iii) an intercept and a linear time trend. We also assume that the error term, i.e., u_t in

(1), is a white noise (panel i), a weakly autocorrelated process as in the non-parametric model of Bloomfield (panel ii), and finally, given the monthly frequency of the series, a seasonal monthly AR(1) process (panel iii). The best model is chosen on the basis of the statistical significance of the estimated coefficients as indicated by their t-statistics. As can be seen, the time trend is required in all cases and the I(1) hypothesis (i.e., $d = 1$) cannot be rejected in any case – in other words, the three series are highly persistent and shocks have permanent effects.

[Insert Table 2 about here]

Next we re-estimate the differencing parameter recursively adding one observation (month) at a time until February 2021. The results based on the autocorrelation model of Bloomfield (1973) for the errors are displayed in Figure 1 (those based on the assumption of a white noise process for the errors are broadly similar and are not reported to save space). It can be seen that this parameter is relatively stable around 1 throughout the Covid-19 period, which implies that the degree of persistence of stock prices has not been affected by the pandemic.

[Insert Figure 1 about here]

Table 3 reports the estimation results over the period up to December 2019 for bond yields and their spread. The same three specifications are estimated as for stock prices. The best model for both yield series includes the intercept only, whilst no deterministic terms are required in the case of the spread. The orders of integration are slightly higher than for stocks; specifically, there is evidence of I(d) with $d > 1$ for the two yield series under the assumptions of white noise and seasonal AR(1) errors; the I(1) hypothesis cannot be rejected for 10-year yields when assuming autocorrelation in the errors as in the model of Bloomfield (1973), whilst it is rejected in favour of mean reversion (i.e., $d < 1$) in the case of 1-year yields. Thus, it appears that bonds behave

differently depending on their maturity. Figure 2 displays the recursive estimates of d (again for the case of Bloomfield errors) over the pandemic period, i.e., adding one observation at a time until the end of the sample in February 2021. It can be seen that, unlike the case of stock prices, the degree of persistence of bond yields appears to have been affected by the Covid-19 pandemic. In particular, the estimated parameter d increases from around 1 to values significantly above 1 in the case of 10-year bond yields; by contrast, the estimated values of d are still significantly below 1 for 1-year bond yields (which implies mean reversion), and the increase in this parameter occurs a few months later. Finally, all values are significantly above 1 in the case of the spread but there is not much evidence of an increase in d over time.

[Insert Table 3 and Figure 2 about here]

To sum up, although a variety of studies had already examined persistence in stock prices and bond yields using fractional integration techniques (see, e.g., Caporale et al., 2020, 2022; Adekoya, 2021; Bala and Gupta, 2021), hardly any had considered the most recent period including the Covid-19 pandemic and examined whether its outbreak coincided with a change in persistence (Štifanić et al., 2020 being one of the few exceptions, though providing relatively limited evidence for stock prices only using wavelet and network methods) – this is instead the focus of our analysis which, as explained above, produces the interesting result that the pandemic has had a significant impact on the stochastic behaviour of bond yields but not of stock prices.

5. Conclusions

This paper analyses the possible effects of the Covid-19 pandemic on the degree of persistence of both US monthly stock prices and bond yields using fractional integration techniques. The model is estimated first over the period January 1966-December 2020 to obtain a measure of the degree of persistence of the series of interest prior to the

Covid-19 outbreak. Then a recursive approach is taken to examine whether or not this has changed during the pandemic period (up to February 2021). Although other studies have provided some evidence on the impact of the Covid-19 pandemic on financial markets (see, e.g., Salisu and Vo, 2020, and Štifanić et al., 2020), the present one is the first to examine within a long-memory framework whether or not persistence of US stock prices and/or bond yields has been affected the Covid-19 pandemic.

We find that the unit root hypothesis cannot be rejected for stock prices while for bond yields the results differ depending on the maturity date and the specification of the error term. In general, bond yields appear to be more persistent, although there is evidence of mean reversion in case of 1-year yields under the assumption of autocorrelated errors. Further, the recursive analysis shows no impact of the Covid-19 pandemic on the persistence of stock prices, whilst there is an increase in the case of both 10- and 1- year yields but not of their spread; in other words, the pandemic has affected bond rather than stock markets, possibly because the former are more directly affected by changes in fiscal policy such as those implemented by the US government to support the economy during the pandemic period.

On the whole, our findings point to a greater degree of market efficiency in the case of stock prices, which appear to be unpredictable since they exhibit a unit root and thus follow a random walk - unlike bond yields, for which there is evidence of some predictability. Volatility persistence is a further important issue to be investigated in future work given the high degree of uncertainty generated by the Covid-19 pandemic (see Baker et al., 2020).

References

Abakah, E.J.A. and Gil-Alana, L.A. (2022). Persistence in US Treasury bonds. *Finance Research Letters*, Elsevier, vol. 45(C).

- Adekoya, O.B. (2021). Persistence and efficiency of OECD stock markets: linear and nonlinear fractional integration approaches. *Empirical Economics* 61, 1415–1433. <https://doi.org/10.1007/s00181-020-01913-4>
- Al-Awadhi, A.M., Alsaifi, K., Al-Awadhi, A., and Alhammadi, S. (2020). Death and contagious infectious diseases: impact of the COVID-10 virus on stock market returns. *Journal of Behavioral and Experimental Finance*, 27.
- Alfred, M and Sivarajasingham, S. (2020). Testing for Long Memory in Stock Market Returns: Evidence from Sri Lanka: A Fractional Integration Approach. *SCIREA Journal of Economics*, Volume 5, Issue 1, February 2020.
- Baker, S. R., Bloom, N., Davis, S.J., Kost, K., Sammon, M. and T. Viratyosin. (2020): “The Unprecedented Stock Market Reaction to COVID-19”, available at <https://nbloom.people.stanford.edu/research>.
- Bala, A., and Gupta, K. (2021). Examining the long memory in stock returns and liquidity in India. *Copernican Journal of Finance & Accounting*, 9(3), 25–43. <https://doi.org/10.12775/CJFA.2020.010>.
- Balcilar, M., Cakan, E., and Ozdemir, Z.A. (2015). Structural breaks, long memory, or unit roots in stock prices: Evidence from emerging markets. *International Econometric Review*, 7 (1) (2015), pp. 13-33.
- Bloomfield, P. (1973). An exponential model in the spectrum of a scalar time series, *Biometrika*, 60, 217-226.
- Caporale, G.M. and M. Cerrato (2020), “The COVID-19 pandemic and the economy: We are fighting a new war”, *Policy Scotland*, 21 May 2020, available at <https://policyscotland.gla.ac.uk/covid-19-pandemic-and-the-economy-we-are-fighting-a-new-war/>
- Caporale, G.M., Gil-Alana, L.A., and Martin-Valmayor, M.A. (2022). Non-linearities and persistence in US long-run interest rates. *Applied Economics Letters*, 29:4, 366-370, DOI: 10.1080/13504851.2021.1897511.
- Caporale, G.M., Gil-Alana, L.A., and Plastun, A. (2018). Is market fear persistent? A long-memory analysis. *Finance Research Letters*, Volume 27, Pages 140-147, <https://doi.org/10.1016/j.frl.2018.02.007>.
- Caporale, G.M., Gil-Alana, L.A., and Poza, C. (2020). Persistence, non-linearities and structural breaks in European stock market indices. *The Quarterly Review of Economics and Finance*, Volume 77, Pages 50-61, <https://doi.org/10.1016/j.qref.2020.01.007>.
- Chen, C.D., Chen, C.C., Tang, W.W., and B.Y. Huang (2009), “The positive and negative impacts of the SARS outbreak: A case of the Taiwan industries”, *Journal of Development Areas*, 43, 1, 281–293.
- Chen, M.H., Jang, S.S., and W.G. Kim (2007), “The impact of the SARS outbreak on Taiwanese hotel stock performance: an event-study approach”, *International Journal of Hospital Management*, 26, 1, 200–212.

Christensen, B.J. and Nielsen, M.O. (2007). The Review of Economics and Statistics. Vol. 89, No. 4, pp. 684-700. The MIT Press.

Demirel, M. and Unal, G. (2020). Applying multivariate-fractionally integrated volatility analysis on emerging market bond portfolios. *Financial Innovation* 6, 50. <https://doi.org/10.1186/s40854-020-00203-3>

Dräger, L., Nguyen, D.B.B., Prokopczuk, M., and Sibbertsen, P. (2020). The Long Memory of Equity Volatility and the Macroeconomy: International Evidence. *Hannover Economic Papers (HEP) dp-667*, Leibniz Universität Hannover, Wirtschaftswissenschaftliche Fakultät.

Eickmeier, S., Metiu, N. and Prieto, E. (2017). Monetary policy effectiveness in times of financial market volatility. *Research Brief 11th Edition*. March 2017. Deutsche Bank Eurosystem.

Hiremath, G.S. and Bandi, K. (2010). Long Memory in Stock Market Volatility: Evidence from India. *Artha Vijnana*, Vol. 52, No. 4, pp. 332-345.

Kasman, A. and Torun, E. (2007). Long Memory in the Turkish Stock Market Return and Volatility. *Central Bank Review*, 2. Pages 13-27.

Martens, M., Van Dijk, D., and de Pooter, M. (2004). Modeling and Forecasting S&P 500 Volatility: Long Memory, Structural Breaks and Nonlinearity. *Tinbergen Institute Discussion Papers 04-067/4*, Tinbergen Institute.

Ramelli, S. and Wagner, A. (2020), "What the stock market tells us about the consequences of COVID-19", in R. Baldwin and B. Weder di Mauro (eds.), *Mitigating the COVID Economic Crisis: Act Fast and Do Whatever It Takes*, A VoxEU.org Book, CEPR Press.

Reisen V.A., F. Cribari-Neto and M. Jensen (2003), "Long memory inflationary dynamics: the case of Brazil". *Studies in Nonlinear Dynamics and Econometrics* 7, 1-16.

Robinson, P.M. (1994) Efficient tests of nonstationary hypotheses, *Journal of the American Statistical Association* 89, 1420-1437.

Robinson, P. M. (1995a) Log-periodogram regression of time series with long range dependence. *Ann. Stat.* 23: 1048–1072.

Robinson, P. M. (1995b) Gaussian semiparametric estimation of long range dependence. *Ann. Stat.* 23: 1630–1661.

Sowell, F., (1992). Maximum likelihood estimation of stationary univariate fractionally integrated time series models. *Journal of Econometrics* 53, 165-188.

Štifanić, D., Musulin, J., Miočević, A., Šegota, S.B., Šubić, R., and Car, Z. (2020). Impact of COVID-19 on Forecasting Stock Prices: An Integration of Stationary Wavelet Transform and Bidirectional Long Short-Term Memory. Complexity, Vol. 2020, Article ID 1846926. <https://doi.org/10.1155/2020/1846926>

Table 1: Descriptive statistics

	N	Minimum	Maximum	Average	Stand. Deviation
NYSE COMPOSITE	661	353.690	14524.800	4391.329	3999.012
NASDAQ 100	457	102.470	12925.380	2124.327	2417.919
S&P500 COMPOSITE	661	63.540	3756.070	816.605	826.154
US DOW JONES	661	607.870	30606.480	7095.753	7273.506
US TREASURY YIELD 10 YEARS	661	2.050	342.620	104.825	72.222
US TREASURY YIELD 1 YEAR	661	13.450	332.320	133.702	65.389
SPREAD B10 vs B1	661	-3.070	3.400	1.048	1.155

Table 2: Estimates of d: Stock indices. Sample period: January 1966-December 2019

Series	No terms	An intercept	An intercept and a linear time trend
i) White noise			
Dow Jones	0.99 (0.93, 1.05)	1.00 (0.95, 1.07)	1.00 (0.95, 1.07)
NYSE	0.99 (0.94, 1.05)	1.03 (0.97, 1.09)	1.03 (0.97, 1.09)
Standard & Poor	0.99 (0.94, 1.06)	1.02 (0.96, 1.08)	1.02 (0.96, 1.08)
ii) Autocorrelation (Bloomfield)			
Dow Jones	0.98 (0.87, 1.08)	0.98 (0.91, 1.07)	0.98 (0.91, 1.08)
NYSE	0.98 (0.89, 1.08)	0.96 (0.88, 1.05)	0.96 (0.87, 1.05)
Standard & Poor	0.98 (0.90, 1.09)	0.98 (0.91, 1.08)	0.98 (0.91, 1.08)
iii) Seasonal monthly AR			
Dow Jones	0.99 (0.93, 1.05)	1.00 (0.95, 1.07)	1.00 (0.95, 1.07)
NYSE	0.99 (0.93, 1.06)	1.03 (0.97, 1.09)	1.03 (0.97, 1.10)
Standard & Poor	0.99 (0.93, 1.05)	1.02 (0.96, 1.08)	1.02 (0.96, 1.08)

The values in parentheses are the 95% confidence intervals for the non-rejection values of d. In bold, the selected specification on the basis of the statistical significance of the deterministic terms.

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Figure 1: Recursive estimates of d from January 2020 to February 2021. Stock indices

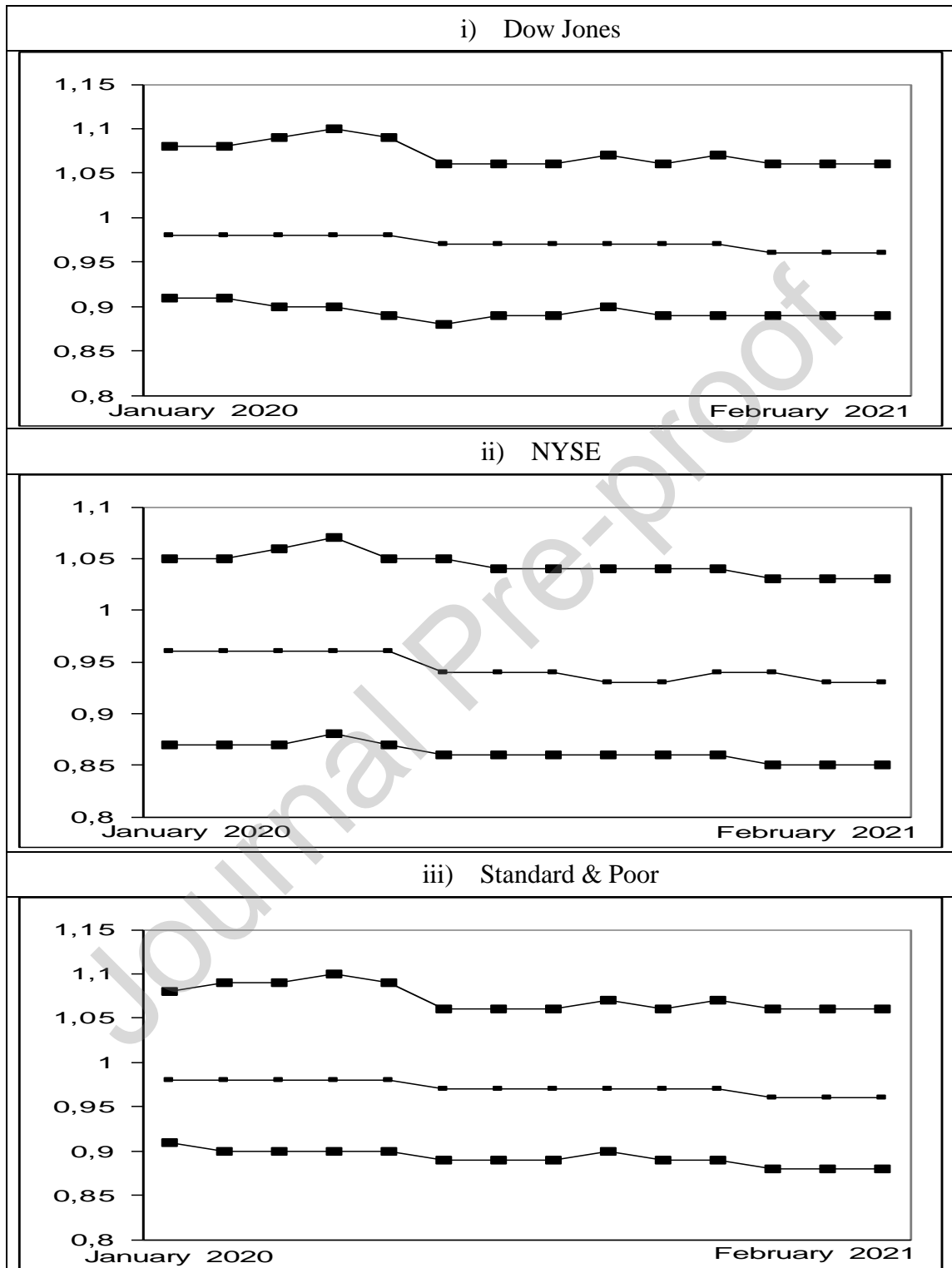
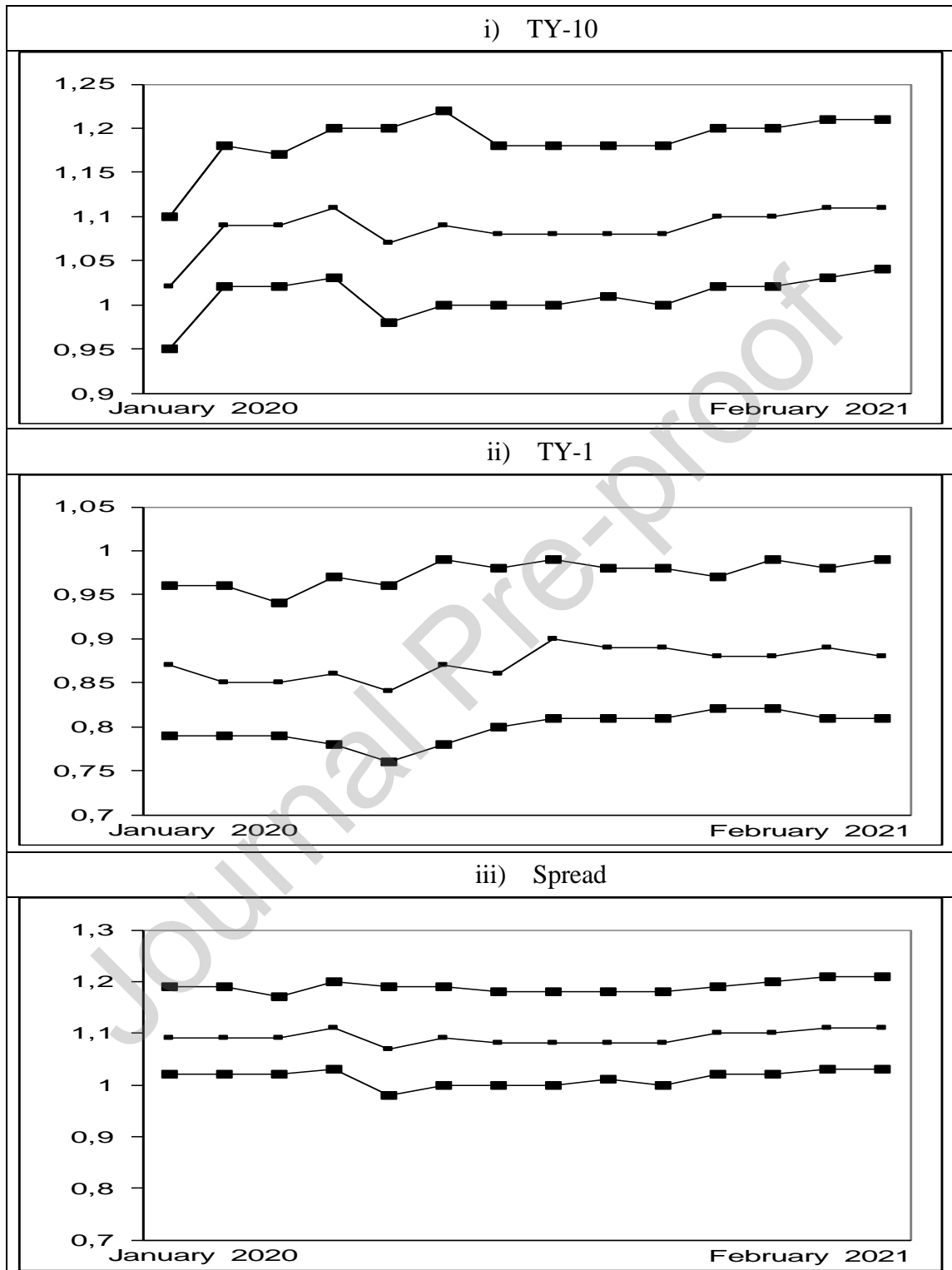


Table 3: Estimates of d: Bond yields. Sample period: January 1966-December 2019

Series	No terms	An intercept	An intercept and a linear time trend
i) White noise			
TY - 10	1.04 (0.99, 1.10)	1.19 (1.13, 1.26)	1.19 (1.13, 1.26)
TY - 1	1.01 (0.96, 1.08)	1.14 (1.06, 1.24)	1.14 (1.06, 1.24)
Spread	1.22 (1.16, 1.29)	1.22 (1.16, 1.29)	1.22 (1.16, 1.29)
ii) Autocorrelation (Bloomfield)			
TY - 10	1.01 (0.94, 1.09)	1.02 (0.95, 1.10)	1.02 (0.95, 1.10)
TY - 1	0.98 (0.90, 1.07)	0.87 (0.79, 0.96)	0.86 (0.78, 0.96)
Spread	1.09 (1.02, 1.19)	1.09 (1.02, 1.19)	1.09 (1.02, 1.19)
iii) Seasonal monthly AR			
Dow Jones	1.04 (0.98, 1.10)	1.18 (1.12, 1.26)	1.18 (1.12, 1.26)
NYSE	1.01 (0.96, 1.08)	1.14 (1.06, 1.23)	1.14 (1.06, 1.23)
Standard & Poor	1.21 (1.16, 1.28)	1.21 (1.16, 1.28)	1.21 (1.16, 1.28)

The values in parentheses are the 95% confidence intervals for the non-rejection values of d. In bold, the selected specification on the basis of the statistical significance of the deterministic terms.

Figure 2: Recursive estimates of d from January 2020 to February 2021. Bond yields



Highlights

- Model estimated first over the period January 1966-December 2020 and then recursive approach to examine whether or not persistence has changed during the following pandemic period (up to February 2021).
- Unit root hypothesis cannot be rejected for stock prices while for bond yields the results differ depending on the maturity date and the specification of the error term.
- Bond yields appear to be more persistent, although there is evidence of mean reversion in case of 1-year yields under the assumption of autocorrelated errors.
- Recursive analysis shows no impact of the Covid-19 pandemic on the persistence of stock prices, whilst there is an increase in the case of both 10- and 1- year bond yields but not of their spread.