Department of Economics and Finance

Economics and Finance Working Paper Series

Working Paper No. 2408

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Testing for Persistence in German Green and Brown Stock Market Indices

July 2024

http://www.brunel.ac.uk/economics

TESTING FOR PERSISTENCE
IN GERMAN GREEN AND BROWN STOCK MARKET INDICES

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July 2024

Abstract

This study examines the stochastic properties of German green and brown stock prices; more specifically,

1. Introduction

ESG (Environment, social, and governance) stands for a set of standards concerning the impact of a business on society and the environment as well as its degree of transparency and accountability. These principles are increasingly being adopted by companies aiming for sustainable investment, environmental considerations being particularly important. Environmentally friendly investments are usually in contrast to ones. Practical policy measures economy were first proposed by Pearce et al. (1989), and over the years the United Nations Environment Programme (UNEP) has engaged in several sustainable investment metrics such as Eurosif; [1] in the GreenMatch survey, Denmark emerged as the greenest country, followed by the United Kingdom and Finland, whilst Germany was ranked 13. [2]

However, more recently, attention in Germany has shifted towards developing green investments to comply fully with ESG principles. The share of green assets in this country relative to brown ones has been going up as a result of environmental considerations as well as of the attractiveness of this type of assets due to their hedging properties; higher demand has pushed their prices up and reduced their expected returns (Pastor et al., 2020). More specifically, the issuance of green bonds by the German

Reboredo and Ugolini, 2020; Yaya et al., 2022; Mensi et al., 2023; Agoraki et al., 2023; Tiwari et al., 2023; Yiming et al., 2024). A common finding is that green assets underperform relative to their brown equivalents (Chang et al. 2012; SSE Initiative, 2017), namely investors tend to pay a price for socially responsible investing (see Auer and Schuhmacher, 2016) as firms with lower ESG scores earn higher returns (Luo, 2022). Further, green growth policies result in investors perceiving a lower risk and thus lead to lower future aggregate stock market returns (Abu-Ghunmi et al., 2023).

One important issue not investigated by the studies discussed above is the degree of persistence of green vis-à-vis brown stock prices and the possibly different impact of the Covid-19 pandemic on their respective stochastic behaviour. The present paper aims to fill this gap in the literature. More specifically, it focuses on the case of Germany

whi0 G21 0 0 1 257.21 759.96 Tm0 g0 G[(e)4(t)-21(a)4(l.,)]TJETQq0.000008871 0 e95.32Qcrm6E841.9

and L is the lag operator; finally, u(t) is an integrated of order 0 or I(0) process which is assumed in turn to be a white noise or to exhibit autocorrelation. In the latter case we use the exponential spectral method of Bloomfield (1973); this is a non-parametric approach to approximate AR structures with very few parameters which performs favour of d > 1 in the cases of Frankfurt and Stuttgart for the green stock prices, and the rest of estimates are also above 1, though the unit root null hypothesis (evidence of d = 1) cannot be rejected. However, for the brown stock prices, the estimates of d are in all cases below 1 except for Munich, but even in this case the estimated value is slightly lower than for its green counterpart. The unit root null is not rejected in any case, which supports the efficient market hypothesis (EMH), at least in its weak form (Fama, 1970). The picture based on the log-transformed data (Table 2) is instead more mixed, specifically the estimates of d are lower for the brown stock prices for Dusseldorf, Frankfurt, Gettex and Stuttgart, while they are higher for Berlin and Munich.

INSERT TABLES 1 AND 2 ABOUT HERE

Next, we allow for autocorrelation in the errors. These results are reported in Table 3 and 4 for the original and logged series respectively. In the former case, the estimates of d are lower than under the assumption of white noise errors, although they are all in the I (1) interval, which is again consistent with the EMH. In the latter case there is a slight increase in the order of integration compared to the white noise case only for Berlin, whilst all the other estimates of persistence are slightly lower in the brown markets. In general, higher degrees of persistence are observed in the green stock markets compared with the brown ones.

INSERT TABLES 3 AND 4 ABOUT HERE

Next, we split the sample into three subperiods, namely pre-Covid-19 (Table 5), Covid-19 (Table 6) and post-Covid-19 (Table 7), setting 11 March 2020 as the start and 5 May 2023 as the end of the pandemic respectively (Ashraf, 2020; Coskun et al., 2023), since the former is the date when the World Health Organisation (WHO) characterised the outbreak as a pandemic and the latter is the date when it declared the end to Covid-19 as a global health emergency.[3]

In the pre-Covid-19 period (before 11 March 2020), higher orders of integration are estimated in the green markets than in the brown ones for Frankfurt, Gettex and Stuttgart with both the original and the logged data, although the differences between the

Kacperczyk. 2022, 2023). However, existing studies have not investigated possible differences between these two types of markets in terms of their degree of persistence, which is a crucial property of asset prices given its implications for market efficiency and policy formulation.

The present study addresses this issue by focusing on representative green and brown stock indices in the case of Germany, a leading country in green investment in the EU, which has been at the forefront of the fight against climate change. It also investigates the possible impact of the Covid-19 pandemic by estimating the model over subsamples as well as the whole sample period. The modelling approach followed is based on the concept of fractional integration, which is more general than and has several advantages over the classical framework only allowing for stationary I (0) and non-stationary I (1) series. The analysis yields a number of new and interesting insights. Specifically, the results indicate a higher degree of persistence in the case of green stock prices vis-à-vis brown ones, although the differences are not statistically significant over the full sample. However, when splitting the sample into three subperiods (pre-Covid-19, Covid-19 and post-Covid-19), statistically significant differences are found. In particular, during the pandemic period the green market appears to have become more efficient relative to the brown one.

contrasting factors: on the on hand, investing in green assets becomes less of a priority during crisis times when the main concern is to reduce the negative impact of exogenous shocks such as the Covid-19 pandemic; on the other hand, demand for such assets as safe havens might increase if financial integration decreases, and thus portfolio diversification opportunities increase, during crisis times. Finally, the estimation of a GARCH (1,1) model for stock returns shows that their conditional volatility is characterised by lower persistence and shorter half-lives in the case of brown stocks.

Future work should extend the analysis to other countries to obtain wider evidence on possible differences in the degree of persistence and market efficiency of green vis-à-vis stock prices. From a modelling point of view, other approaches such as recursive or rolling window estimation could be used in order to allow for the possibility of a gradual evolution over time of the parameters of interest. Further, possible nonlinearities could be examined by using, for example, orthogonal polynomials in time as in Hamming (1973) and Bierens (1997) in the context of fractional integration as in Cuestas and Gil-Alana (2016), or Fourier functions in time as in Gil-Alana and Yaya (2021), or neural networks as in Yaya et al. (2021b).

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Table 4: Estimated coefficients. Logged data. Autocorrelated errors

	Green Stock Market Prices		Brown Stock Market Prices	
Series	d (95% interval)	Intercept (tv)	d (95% interval)	Intercept (tv)
BERLIN	0.96 (0.90, 1.03)			

Table 8: Estimates of volatility persistence in green and brown stock returns

Green Stock Market Returns	**GARCH estimates** (, ,)	**Persistence** +	**Half-life**
Berlin	6.37E-06, 0.1069, 0.8853	0.9922	88.5
Dusseldorf	3.60E-06, 0.0919, 0.9028	0.9947	130.4
Frankfurt	4.51E-06, 0.0771, 0.9143	0.9914	80.3
Gettex	4.76E-06, 0.0883, 0.9017	0.9900	69.0
Munich	5.67E-06, 0.0716, 0.9169	0.9885	59.9
Stuttgart	6.70e-06, 0.0994, 0.8847	0.9841	43.2
Brown Stock Market Returns	**GARCH estimates** (, ,)	**Persistence** +	**Half-life**
Berlin	1.32E-05, 0.1125, 0.8458	0.9583	16.3