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Green economy and stock market returns: Evidence from European stock markets☆

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ABSTRACT

Green economy is the way forward to achieve economic, social and environmental, sustainable development. However, to accelerate the transition to green economy, private sector companies need to understand the impact of imposing green polices and activities on the economy. Therefore, this paper examines the impact of green growth on future aggregate stock market returns on European stock exchanges. Using fixed effects model, the results show that green growth policies result in lower future aggregate stock market returns consistent with the investors' perceived reduction in risk argument. The findings of this paper enhance our understanding of how transition to a more sustainable green economy could impact the aggregate return of financial markets. The results remain unchanged after estimating standard errors clustered by country, by year and by both country and year. However desirable it is to adopt a green economy, it is important to implement the right measures to support it sensitively, without imposing heavy costs that severely affect economic health.

1. Introduction

On 25 September 2015, the UN General Assembly adopted the 17 sustainable development goals (SDGs), which were built on the Millennium development goals, and cover the economic, social and environmental dimensions of sustainable development (UN (United Nations, General Assembly), A/RES/70/1 (2015)),[1,2] Actually, sustainable development is the "most resilient approach" to reduce environmental volatility and other potential crises (Babkin et al., 2023) and green economy is considered to be one of the key tools to achieve sustainability (UN, A/RES/66/288, 2012).[3] "A green economy (GE) can be defined as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2010, p. 4). This definition clearly captures the economic, social and environmental dimensions of sustainable development. "In its simplest expression, a green economy is low-carbon, resource efficient, and socially inclusive" (UNEP, 2011 p. 16). However, the transition to a green economy requires large investments, a significant part of which should come from the private sector (Inderst et al., 2012). In addition, environmental problems are so serious that they expose financial institutions and businesses to a major risk of disrupting their operations and therefore they should work toward mitigating this risk (Clark et al., 2018). Unfortunately, there is less empirical evidence of the effectiveness of green investment projects that address sustainable development (Clark et al., 2018).

Green investment exists across the globe despite the fact that the concept of transition to a green economy has not been clearly defined (FTSE Russell, 2018). For example, green venture capital, in terms of both amount and number of deals, has been gaining importance in the US, Europe and China, among other countries (Criscuolo and Menon, 2015). It was shown that green venture capital investment in the green sector is encouraged by environmental policies that have a long-term

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[1] https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
[2] https://www.un.org/development/desa/disabilities/envision2030.html
[3] https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/66/288&Lang=E

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perspective such as feed-in-tariffs (Criscuolo and Menon, 2015). Another emerging form of green financing is green bonds,[4] which are issued not only by public institutions but also by corporations with increasing investing interest from institutional investors (Clapp, 2014).

Interestingly, there are investors who use environment, social and governance framework to assess the opportunities and risks of their investment decisions, taking both financial and non-financial factors into account (OECD, 2018). Actually, a survey conducted by the OECD on large pension funds and large public pension reserve funds in 2016 found that 29 funds have invested in green investments with a trend of including into the decision-making process the environmental impact of their investments (OECD, 2018). Clearly, investors are now using a broader framework in analysing their investments that considers not only the financial consequences of their investment decisions but also non-financial consequences that make them closer to the United Nations SDGs (OECD, 2018). In fact, the green economy, measured in terms of market capitalization, accounts for about 6% of the value of publicly listed companies across the globe (FTSE Russell, 2018). Nevertheless, there are barriers to private sector engagement in green investment to achieve environmental goals and the broader SDGs (Clark et al., 2018). These barriers include, among others, the information gap on the non-monetary impacts of environmental and social risks associated with investment decisions, the undervaluation of natural resources, and insufficient voluntary commitment (Clark et al., 2018).

But what makes investors invest in green economy? The objective of utility maximizing investor is to maximize their wealth, i.e. to maximize the present value of their investments (Auerbach, 1979). The traditional shareholder wealth maximization objective has viewed environmental activities as involving costs without corresponding benefits, hence rational behavior dictates minimizing such costs as much as possible (Feldman et al., 1997). Another view sees environmental expenses and activities as enhancing financial performance through their positive impact on the operating activities of the firm (Feldman et al., 1997). Therefore, it could be argued that if investors perceive a reduction in risk, they will require lower return on firm's stock (Feldman et al., 1997). Nevertheless, empirically, it is found that companies that pursue sustainability solutions generally have experienced higher returns, even after controlling for risk and hence results in value creation (ING Economics Department, 2015).

In light of this conflicting views of the impact of sustainable green investments on stock returns, the question that naturally arises is, *What impact green growth activities and policies have on aggregate stock market returns?*. Therefore, the current paper fills in this gap by investigating the impact of green growth policies and activities on future stock market returns on European stock exchanges. It hypothesizes that the higher the growth in green activities and policies in the economy, the lower the required returns on the market portfolio due to reduction in perceived investment risk. To the best of the authors knowledge, this is the first attempt to explore such impact on the aggregate stock market return. The choice of European markets comes from the fact that, Europe, as a group, is the second largest part of the green economy in term of green revenue exposure (FTSE Russell, 2018), which makes the relevant market for investigating the issue at hand.

Our results, briefly stated, are that two principal components have a significant negative effect on one-year stock market returns. The principal components include mean feed-in tariff for solar electricity generation and energy productivity. This implies that policies that promote green economic growth reduces the perceived risk by investors and consequently they require lower return on market portfolio.

The rest of the paper is organized as follows; Section 2 discusses the relationship between green economy and stock markets; Section 3 describes the data and methodology used in the paper, Section 4 presents the findings and discusses the results and Section 5 concludes.

2. Literature review and hypothesis development

Theoretically, two competing hypotheses were proposed to explain how green, socially responsible, eco-conscious investing might impact stock prices: the "shunned-stock hypothesis" and the "errors-in-expectations hypothesis" (Derwall et al., 2011). On one hand, according to the shunned-stock hypothesis, socially responsible/green investors are value driven and hence, based on the incomplete information model of Merton (1987), they hold investment not for profit reasons but rather for non-pecuniary reasons which causes such stocks to trade at a premium, i.e. lower return, compared with irresponsible investment due to the limited risk sharing of the latter (Derwall et al., 2011). On the other hand, the errors in expectation hypothesis suggests that socially responsible stocks are systematically undervalued and hence generate higher returns (Derwall et al., 2011).

In another argument, Feldman et al. (1997) found that environmental activities by firms have not only reduced costs but also reduced the perceived riskiness of the firms resulting in a lower cost of equity and higher stock prices. They build a conceptual framework which links cost of equity and firm value with its environmental management systems and performance. They argue that the channel through which the firm's enhanced environmental activities are translated into a lower cost of capital and higher market value is when the firm's environmental investment policies and performance are communicated to investors. Investors will then assess the impact on the firm's environmental risks (Feldman et al., 1997). If investors perceive a reduction in this risk, they will lower the required rate of return on the firm's equity capital and hence its stock price increases (Feldman et al., 1997). Furthermore, Feldman et al. (1997) point out that the environmental management systems in their stu7dy mean not only compliance with related environmental laws but also the environmental activities that are integrated into the firm's operations covering supply chain activities including product design, processes and others. They further state that such linkage results in "environmental transformation" companies. They argue that firms that disclose more information about their environmental activities are usually perceived by investors as less risky. They link environmental risk to systematic risk that is measured by beta and argue that when the environmental risk of the firm changes, its beta changes accordingly. However, it is noteworthy that the cost of environmental activities is expected to affect not only the systematic risk, but also the expected cash flows.

On the empirical front, some authors found evidence in support of the shunned stock hypothesis that predicts ethically irresponsible stocks experience positive anomalous returns (Derwall et al., 2011), while others found that green equities and green bonds outperform their non-green equivalents (SSE Initiative, 2017). Furthermore, El Ghoul et al. (2011) found that firms that invest in environmental policies reduce their cost of equity capital. They interpret the results as market participants value firms that are concerned about environmental issues. In addition, Chang et al. (2012) found that green mutual funds in the USA have been outperformed by their equivalent traditional funds. Similarly, Luo (2022) investigated how environment, social and governance (ESG) score of the firm impacts its stock return. They found a negative relationship where firms with higher ESG score generate lower returns and those with lower ESG generate higher returns. Furthermore, they found that the premiums for the environment and social dimensions are greater than the aggregate ESG premium. This is also confirmed by Auer and Schuhmacher (2016) who reported evidence of socially responsible stocks generating lower returns in Europe, conditional on the industry and the ESG dimension.

Building on the theoretical arguments and empirical findings in the literature, it can be assumed that green growth policies are expected to reduce the cost of equity capital due to the reduction in perceived systematic risk. Therefore, this paper argues that promoting and imposing

[4] A bond which is used to raise money for environment-friendly projects (Clapp, 2014)

environmental and green policies would generally reduce returns on aggregate stock market portfolio because of reduction in environmental risk, this impact is also in line with the shunned-stock hypothesis which predicts that stocks of companies that are socially responsible will have lower returns.

Therefore, as the above studies focused on the impact of green and socially responsible investing activities on stock prices of stocks, to the best of the authors' knowledge, there has been no study that examines the impact of green economy activities and policies on aggregate stock market returns. At macro level a number of macroeconomic variables are identified by the OECD to capture the main aspects of green growth (OECD, 2017). The OECD called these macro variables "Green Growth Indicators". They can be used to inform both policy makers and the public about the progress of a particular economy to green growth (OECD, 2017),[5].[6] The OECD green indicators are organized around the following four sets of indicators that capture the major aspects of green growth: environmental and resource productivity; the natural asset base; environmental dimension of quality of life; and economic opportunities and policy responses (OECD, 2017). Social economic context indicators are added to them to complete the picture (OECD, 2017). But *why could green growth indicators affect stock market returns?*

In fact, macroeconomic variables are candidate risk factors that could affect stock prices through affecting firm cash flows and/or required rate of return (cost of capital) (Flannery and Protopapadakis, 2002). Literature has documented that fluctuations in macroeconomic variables affect stock prices as stock market investors discount the economic conditions in their investment decisions (Chang et al., 2015). Referring to Merton's (1973) Intertemporal Capital Asset Pricing Model, Flannery and Protopapadakis, (2002, p.755) state, "Any economic variable whose movements are correlated with the marginal utility of consumption is a potential factor in equilibrium. The intuition that macroeconomic conditions cause, or at least proxy for, changes in the investment opportunity set is appealing." Furthermore, Fama and French (1989) argue that the inverse relationship between expected returns on stocks and business conditions is in line with modern asset pricing models such as the intertemporal asset pricing models of Merton (1973) and Breeden (1979), which are characterized by a consumption smoothing feature. According to Merton (1973) and Breeden (1979) variables that cause changes in the future investment opportunity set that investors face, as well as the level of consumption, are candidates for priced risk factors (Flannery and Protopapadakis, 2002). The expected cash flows of the firm and/or its discount rate of return could be affected by changes in the macroeconomic variables, therefore they are good proxies for the risk factors in the multifactor asset pricing models of Merton (1973), Breeden (1979) and Ross (1976) (Flannery and Protopapadakis, 2002).

Flannery and Protopapadakis (2002) use 17 macroeconomic series to examine their impact on stock returns. They find several macro variables that are possible risk factors candidates. Innovations in PPI, CPI and money supply negatively affect the level of equity returns while announcements in employment, housing, trade balance and money supply affect equity returns volatility (Flannery and Protopapadakis, 2002). Fama and French (1989) find term spread, default spread and dividend yield capture common time-varying risk premiums in expected stock returns. They suggest that dividend yield and default spread capture time-varying risk premium related to long term business conditions, which they call the default premium. They further suggest that the term spread captures a time-varying risk premium related to short term business conditions, identified as a maturity or term premium which compensates investors for the risk inherent in stocks measured by the discount rate. Fama and French (1989) conclude that expected returns on stocks are high (low) when business conditions are weak (strong). They used lagged explanatory / forecasting variables. Moreover, Campbell and Thompson (2008) find that many variables can predict excess stock returns given that restricted regressions are used. They use simple rather than log return because of the high stock market volatility at the beginning of the study period, which they argue depressed log stock market returns. They report that term spread, and Treasury bill rate are predictors of aggregate market returns. They show that the consumption wealth ratio of Lettau and Ludvigson (2001) and the long-term bond yield also have predictive power for aggregate stock market returns.

Theatrically, firm risk can be divided into business risk, financial risk, and environmental risk (Feldman et al., 1997). Therefore, it can be argued that green growth indicators, which measure economy progress to a green economy, capture environmental risk. Changes in these indicators capture changes in environmental risk that firms in the economy are facing, and hence affect investors' future investment opportunity set. Therefore, it is expected that changes in green growth indicators will affect stock market prices and their returns. Consequently, our hypothesis can be formulated as following*:*

H_0: Green policies and activities in the economy (proxied by changes in green growth indicators) reduces future aggregate stock market returns due to reduction in environmental risk perceived by investors.

3. Data and methodology

3.1. Data

Annual green growth indicators for 19 European countries were obtained from OECD.*Stat.*[7] In addition, the annual CPI, long-term and short-term interest rates were obtained from OECD.*Stat.*[8] Long-term and short-term interest rates were used to calculate the term spread and CPI was used to calculate inflation. Annual prices of stock market indices were obtained from OECD.*Stat,*[9] which were used to calculate the annual market returns. The sample period is 2000–2018. The beginning and end of the sample period 2018 were dictated by the availability of data at the time the research was conducted.

There are 19 European countries for which the required data are complete and available: Austria; Belgium; Czech; Denmark; Finland; France; Germany; Greece; Ireland; Italy; Netherlands; Norway; Poland; Portugal; Slovakia; Spain; Sweden; Switzerland and the UK.

3.2. Methodology

In order to investigate whether changes in green economy indicators capture variation in aggregate stock market returns, we use the following model that assumes the presence of a number of potential macroeconomic risk factors.[10] The econometric model is in line with a model of conditional mean of excess return on a number of lagged conditioning macroeconomic factors (Ludvigson and Ng, 2007) or simply a model of excess market return on a number of lagged predictive macroeconomic variables (Fama and French, 1989; Lettau and Ludvigson, 2001; Rapach et al., 2005; Flannery and Protopapadakis, 2002)

$$SM\ Return_{it} = \alpha + \sum_{n=1}^{N} \beta_n * MC_{i,n,t-1} + \sum_{k=1}^{K} \gamma_k * GE_{i,k,t-1} + \varepsilon_{it} \tag{1}$$

SM Return$_{it}$ is the natural logarithm of return on stock market index

[5] OECD Green Growth Indicators - OECD Statistics - OECD.org, available at https://stats.oecd.org

[6] https://read.oecd-ilibrary.org/environment/green-growth-indicators-2017_9789264268586-en#page9

[7] https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH

[8] https://stats.oecd.org/index.aspx?queryid= 6779#

[9] https://stats.oecd.org/index.aspx?queryid= 6779

[10] It is important to note here that macroeconomic factors that have predictive power of stock market returns are not necessarily priced risk factors, however they are potential risk factors (Flannery and Protopapadakis, 2002)

for country i at year t (Ludvigson and Ng, 2007). $MC_{i,n,t-1}$ is macroeconomic variable n for country i at year t-1 that was found in the literature to be a potential candidate of risk factor or has predictive power. Among these potential risk factor candidates are inflation (Chen at al, 1986; Flannery and Protopapadakis, 2002; Humpe and Macmillan, 2009; Rjoub et al., 2009), term spread (Chen at al, 1986; Fama and French, 1989; Campbell and Thompson, 2008, Rjoub et al., 2009), default spread (Chen at al, 1986; Rjoub et al., 2009), money supply (Bilson et al., 2001; Humpe and Macmillan, 2009; Rjoub et al., 2009), exchange rate (Bilson et al., 2001; Rjoub et al., 2009), and economic activity measured by GDP or industrial production (Chen at al, 1986; Humpe and Macmillan, 2009; Bilson et al., 2001).

The choice of the macroeconomic variables to be included in Model (1) is based on both relevant literature and data availability. Inflation and term spread are found to be significant by many authors (Chen at al, 1986; Fama and French, 1989; Flannery and Protopapadakis, 2002; Rjoub et al., 2009), therefore, they are employed as possible risk factors that have predictive power for future stock returns. The paper uses the change in inflation in line with Chen et al. (1986) and Flannery and Protopapadakis (2002) to proxy for unexpected (surprise) inflation. Interestingly, it was found to capture a time-varying element of expected stock returns that is related to time-varying short-term business conditions (Fama and French, 1989). Other variables such as exchange rates, purchasing power parity and real activity measured by GDP are already included in the socio-economic dimension of the green growth indicators, therefore are not included separately in the model. We could not include default spread in the model due to data unavailability. β_n is the coefficient on the macroeconomic variable n to b estimated, and N is the number of macroeconomic variables.

$GE_{i,k,t-1}$ is a candidate for a green economy indicator k for country i at year t-1, which is extracted from the set of the green growth indicators using principal component analysis. There are 40 green growth indicators used in the study, which comprise indicators for environmental and resource productivity, the natural asset base, environmental dimension of quality of life, economic opportunities and policy responses, and social economic indicators (OECD, 2017).

While we use the OECD indicators unchanged, it is worth noting that some of them may not be ideal for our purposes as they may not be subject to amelioration by human action. For example the country estimates for PM2.5 include "both anthropogenic and natural sources" (OECD, 2017 p.87). The chart on the same page shows Saudi Arabia to be the worst country in the world for PM2.5 pollution (the next countries being India and China), but this could be due to Saudi Arabia being mostly desert. The determinants of ozone levels are complex but include "biogenic emissions of ozone precursors" (OECD, 2017 p.89). Radon is emitted naturally from rocks and soil and the levels vary widely depending on the local geology, although in this case remedial work can reduce radon exposure inside buildings (UK Health Security Agency, 2022). Thus, there does appear to be some room for the OECD's green growth indicators to be improved in the future if they are being used to show how environmental quality of life could be ameliorated by human action.

We cannot include all the indicators in the model because of the degrees of freedom problem (Ludvigson and Ng, 2007). Therefore, principal component analysis (PCA) is used to reduce a large set of variables to a small number of factors (Ludvigson, and Ng, 2007). γ_k is the coefficient on the extracted predictive green factor k and K is the number of extracted factors from the green growth indicators set. PCA is applied to the set of green growth indicators after the indicators are transformed by taking the first difference and standardized before estimation following Ludvigson and Ng (2007). The number of extracted factors is 40, however, we selected only 12 which have eigenvalues greater than one (SAS[11]; Kaiser, 1960).

Finally, ε_{it} is composed of two components: a country specific component (λ_i) and a unique idiosyncratic component (u_{it}) (Petersen, 2009). If some variables are omitted from Equation (1), the time-constant country effect (λ_i) may become correlated with the independent variables and hence endogeneity problem arises (Abdallah et al., 2015). In such cases the OLS estimator will be inconsistent, therefore, fixed effects estimation is used to deal with the omitted variables problem (Abdallah et al., 2015). More specifically, the fixed effects estimation handles the omitted variable problem by subtracting the time mean of the variable from each observation, which results in eliminating the time-invariant effect (λ_i). Hence, this paper estimates Equation (1) [12] using static panel data methods, fixed effects and random effects. In addition, Hausman (1978) test is used to select between the two models; random effect and fixed effect, and standard errors are estimated by clustering: by country, by year, and by country and year (Petersen, 2009). Stata 16 used to carry out the statistical analysis.

4. Results and discussions

Table 1 shows descriptive statistics for the variables that are included in model (1). Panel A shows that annual market returns average 1.78 % with a standard deviation of 20.36 %. The high variation in stock market returns also manifested itself in the maximum and minimum observations, from − 59.34 % to + 71.72 %. Interestingly almost all of the variables, including the principal components (PCs) in panel B, show high variation as evidenced by their corresponding standard deviations and the maximum and minimum observations.

Table 2 shows that stock market return in these 19 European countries is significantly negatively correlated with the term spread, the second and the fifth principal components, while it is significantly positively correlated with the third and the ninth principal components. The highest correlation between the predictive variables (explanatory variables) is between the term spread and PC2 (32 %). The table shows that multicollinearity is not a problem, and this is confirmed by the VIF as we found the highest VIF is 1.38 with a VIF mean of 1.07.

In panel data the independence assumption of the OLS residuals is often not met, hence residuals from OLS estimation may suffer across time or across firms' correlations resulting in biased standard errors (Petersen, 2009). In the presence of firm fixed effects (country effect in the terms of our study), Petersen (2009) found that standard errors of OLS, Fama and MacBeth (1973) and panel modified Newey-West standard errors are downward biased, but the latter has a small bias. However, when including country dummies, the OLS estimation of standard errors become unbiased (Petersen, 2009). Therefore, in order to examine whether green growth activities and polices have an impact on aggregate stock market returns, Equation (1) was estimated using five specifications of a fixed effects model (Table 3). Fixed effect is used because Hausman (1978) test (Petersen, 2009) shows that the fixed effects model is more appropriate than the random effects model with chi-square of 22.18 and p-value of 0.0005.

Specification 1 in Table 3 shows that both unexpected inflation (change in inflation) and term spread are significant. The signs of the coefficients on inflation and term spread are consistent with previous literature (Flannery and Protopapadakis, 2002; Fama and French, 1989). Fama and French (1989) find that term spread tracks variation in stock market expected returns with a positive sign. They interpret this to be related to the short-term business cycle. It captures the component of expected stock market return (term premium) that is high around

[11] https://support.sas.com/publishing/pubcat/chaps/55129.pdf

[12] Rapach et al. (2005) pointed out that it would be interesting to use panel model to estimate the predictive regression model for all countries together (footnote 25)

Table 1
Descriptive statistics.

Variable	Mean	Standard deviation	Minimum observation	Maximum observation
Panel A				
Return	0.0178	0.2036	-0.5934	0.7172
Inflation (change)	-0.0002	0.0473	-0.2349	0.2069
Term-spread	1.6226	2.1034	-5.0400	21.9300
Panel B				
pc1	0.0000	2.5129	-6.8302	6.5833
pc2	0.0000	2.3896	-13.2770	8.9370
pc3	0.0000	2.0663	-6.3390	13.9394
pc4	0.0000	1.4736	-9.4153	3.9671
pc5	0.0000	1.4223	-16.6277	6.5290
pc6	0.0000	1.3631	-7.9917	4.0332
pc7	0.0000	1.2536	-4.3841	4.2465
pc8	0.0000	1.2396	-11.6827	3.2355
pc9	0.0000	1.1747	-4.1433	3.7559
pc10	0.0000	1.1591	-4.7278	5.7637
pc11	0.0000	1.0356	-6.0435	7.4780
pc12	0.0000	1.0278	-3.2336	3.7797
PANEL C	Coefficient (P-value)			
Skewness_e	-0.3697 (0.0300)			
Kurtosis_e	0.0460 (0.8730)			
Skewness_u	-20.8478 (0.0000)			
Kurtosis_u	85.0472 (0.0000)			
Joint test for Normality on E:	chi2(2) (Prob > chi2)	4.73(0.0938)		
Joint test for Normality on u:	chi2(2) (Prob > chi2)	5520.86(0.0000)		

Table 1 reports descriptive statistics for the variables used in the model. Return is the natural logarithm of stock market return; Inflation is the change in inflation rate. Term spread is the difference between the long-term and short-term interest rates. PC1-PC12 are the first 12 principal components with eigenvalues that are greater than 1, extracted from a set of 40 green growth indicators using principal components analysis. The green growth indicators are transformed and standardized before the principal components are estimated. Panel C reports normality test based on Alejo et al. (2015)

business cycle troughs (poor times) and low around peaks (good times) (Fama and French, 1989). Fama and French (1989) further argue that the term premium captures discount rate risk.

On the other hand, inflation surprises depress stock values (Flannery and Protopapadakis, 2002). Consistent with the argument that macroeconomic variables proxy for changes in the investor's investment opportunity set, inflation surprises might induce changes in the differences in expected return among assets (Flannery and Protopapadakis, 2002). This finding is also consistent with Chen et al. (1986) who interpret the negative risk premium of unexpected inflation as investors seeing the stock market as a hedge compared with other types of assets that usually have fixed nominal return.

Specifications 2–5 show that the three extracted green growth principal components, which were extracted from the set of green growth indicators, are negatively related to next year stock market returns. Among the extracted 12 PCs only three PCs (PC2, PC3 and PC9) were found to significantly forecast next year stock market returns, whether they are included individually (specification 2–4) or together (specification 5) in the model. The negative relationship between average stock market return and the three principal components; PC2, PC3, and PC9, is confirmed in Fig. 1. The figure shows that, on average, the movement of the three PCs in a particular year is followed by an opposite movement in market return and hence confirms the predictability of market return by green growth indicators. This indicate that

Table 2
Correlation matrix of the variables.

	Return	Inflation	Term- spread	pc1	pc2	pc3	pc4	pc5	pc6	pc7	pc8	pc9	pc10	pc11	pc12
Return	1.0000														
Inflation	**-0.1111**(0.0530)	1.0000													
Term-spread	**0.0912**(0.1018)	-0.0279(0.6176)	1.0000												
pc1	-0.0907(0.1038)	-0.0265(0.6452)	0.0427(0.4447)	1											
pc2	**-0.1624**(0.0034)	-0.0188(0.7437)	**0.3240**(0.0000)	0.000(1.000)	1										
pc3	-0.0824(0.1397)	-0.0114(0.8435)	0.0253(0.6502)	0.000(1.000)	0.000(1.000)	1									
pc4	-0.0785(0.1594)	0.0005(0.9933)	**-0.2876**(0.0000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1								
pc5	-0.0613(0.2723)	-0.0299(0.6033)	0.0757(0.1746)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1							
pc6	**0.1043**(0.0612)	0.0306(0.5957)	**0.1352**(0.0150)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1						
pc7	-0.0299(0.5928)	-0.0823(0.1524)	-0.0609(0.2752)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1					
pc8	-0.0810(0.1462)	0.0872(0.1293)	**-0.1485**(0.0075)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1				
pc9	**-0.0922**(0.0982)	**0.1526**(0.0077)	0.0601(0.2815)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1			
pc10	0.0001(0.9983)	-0.0162(0.7782)	**0.1042**(0.0614)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1		
pc11	0.0388(0.4867)	**0.1560**(0.0064)	0.0169(0.7620)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1	
pc12	-0.0143(0.7977)	**0.0494**(0.3908)	-0.0554(0.3213)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	0.000(1.000)	1

Table 2 reports the correlation coefficients for the variables with p-values in parentheses. Return is the natural logarithm of stock market return. Inflation is the change in inflation rate and term spread is the difference between the long-term and short-term interest rates. PC1-PC12 are the first 12 principal components, with eigenvalues that are greater than 1, extracted from a set of 40 green growth indicators using principal components analysis.

Table 3
Fixed effects regressions: Green growth and aggregate stock market returns.

Variable	Spec.1	Spec.2	Spec.3	Spec.4	Spec.5
Intercept	.0063(0.40)	-.0042(−0.28)	.0085(0.55)	.0034(0.22)	-.0054(−0.36)
inflation	-.4261 * (−1.83)	-.4382 * (−1.94)	-.4333 * (−1.88)	-.3134(−1.35)	-.3303(−1.48)
term spread	.0201 * ** (3.19)	.0270 * ** (4.24)	.01942 * ** (3.10)	.0227 * ** (3.62)	.0293 * ** (4.67)
PC2		-.0203 * ** (−4.09)			-.0212 * ** (−4.37)
PC3			-.0125 * *(−2.24)		-.0131 * *(−2.46)
PC9				-.0304 * ** (−2.93)	-.0314 * ** (−3.14)
F-Statistic	6.98 * **	10.49 * **	6.4 * **	7.64 * **	9.83 * **
R2	8.34 %	13.48 %	9.95 %	11.05 %	18.18 %

Table 3 reports the results of estimating Equation (1) using a fixed effects model. INTERCEPT is the intercept, INFLATION is change in inflation rate and TERM SPREAD is the difference between the long-term and short-term interest rates. PC2, PC3 and PC9 are the second, third and ninth principal components that are extracted from a set of 40 green growth indicators using principal components analysis. The green growth indicators are transformed and standardized before the principal components are estimated. t-values are in parentheses. * , * *, * ** indicate significance at the 1 %, 5 % and 10 % levels respectively. Spec.1- Spec.5 are specifications 1–5.

green growth indicators are candidate risk factors that potentially capture environmental risk.

Green growth indicators are categorized into four groups: environmental and resource productivity, the natural asset base, environmental dimension of quality of life, and economic opportunities and policy responses in addition to the social economic indicators (OECD, 2017). In order to understand what actual green growth indicators are at play, we explore the weights of each principal component on the original indicators to understand the association between the extracted factors and the original dataset. 20 % weight (absolute value) is used as a cut-off point, this is based on the finding that 20% is the highest weights for two factors (PC2 and PC3) while PC9 has weights up to 40%.

We find that PC2 has the largest negative weights on real GDP variables, which indicates a positive relationship between real GDP and future stock market returns. This is unsurprising as Vassalou (2003) found that the portfolio that mimics the news related to future GDP growth is priced in the cross section of stock returns with a positive risk premium. Furthermore, Vassalou (2003) shows that the value and size risk factors of the Fama and French three-factor model do in fact capture news linked to future GDP growth.

Furthermore, the paper finds that the third principal component (PC3) weighs heavily on energy productivity, which may indicate a greater transition to green economy. As the sign of the coefficient of PC3 is negative this may indicate that investors are perceiving lower future environmental risk and hence require lower return. Finally, the ninth principal component (PC9) has the highest weights on mean feed-in tariff for solar PV electricity generation, which may indicate a promotion of green policies reduces the perceived risk by investors and hence reduces the required rate of return. Environmental taxes and transfer subcategory is part of the economic opportunities and policy responses category, which "aim at capturing the economic opportunities associated with green growth (e.g., markets for environmentally related products and associated employment. They monitor policy measures to promote the transition to green growth and to remove barriers to the transition" (OECD, 2017, p.16). Our findings are consistent with Alessi et al. (2023) who reported that European investors accept lower returns on greener assets. Furthermore, Lööf et al. (2022) find that companies with higher ESG ratings have lower risk, more specifically, they report that the higher the ESG rating, the lower the downside risk and the lower the upside return potential.

In summary, the results suggest that policies that promote green growth reduce future stock market returns which could be attributed to investors' perception of lower risk in the market, specifically, lower environmental and social risk.

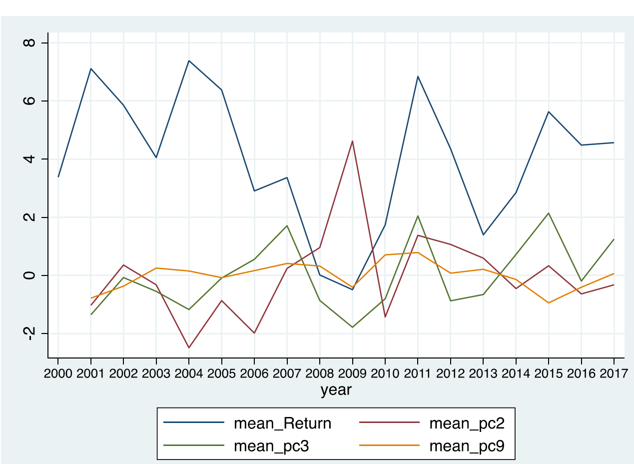

Fig. 1. Movement of Stock Market Return, PC2, PC3, and PC9 over time. Mean_Return: the average return (percentage return) for all stock markets in the sample, mean_pc2: is the average value of pc2 for all markets, mean_pc3: is the average value of pc3 for all markets, mean_pc9: is the average value of pc9 for all markets.

5. Further econometric checks

To check the robustness of our results, we run a battery of tests as reported in Table 4. The robustness tests that are carried out draw on Petersen (2009) who addresses the importance for correcting standard errors for correlation across countries and correlation across time (years) in Panel data.

First, we assume the presence of a fixed country effect, where residuals and independent variables are serially correlated (correlated

Table 4
Robustness Check.

Variable	clustered (by country)	clustered (by year)	clustered (country & year)
Intercept	-.0054(−0.29)	-.0054(−0.09)	-.0780 * *(2.38)
inflation	-.3303(−1.60)	-.3303(−1.40)	-.3303(−1.42)
term spread	.0293 * *(2.79)	.0293(1.63)	.0293(1.51)
PC2	-.0212 * ** (−4.69)	-.0212 * (−1.97)	-.0212 * *(−2.04)
PC3	-.0131 * *(−2.30)	-.0131(−1.37)	-.0131(−1.35)
PC9	-.0314 * *(−2.58)	-.0314 * * (−2.36)	-.0314 * *(−2.23)
F-Statistic	10.88 * **	3.70 * *	2.67 * **
R2	18.18%	18.18%	18.18%

Table 4 reports the results of estimating Equation (1) using a fixed effect model. INTERCEPT is the intercept, INFLATION is the change in inflation rate and TERM SPREAD is the difference between the long term and short term interest rates. PC2, PC3 and PC9 are the second, third and ninth principal components that are extracted from a set of 40 green growth indicators using principal components analysis. The green growth indicators are transformed and standardized before the principal components are estimated. T-values are in parentheses. * , * *, * ** indicate significance at the 1%, 5% and 10% levels respectively.

across time for the same country), though independent of each other (Petersen, 2009). To correct for this bias standard errors clustered by country are calculated (Petersen, 2009) as shown in column 1 in Table 4 using the fixed effect model.

Then we assume the presence of a time effect in both the residuals and independent variables. In this situation, the clustered standard errors are more accurate, although still underestimated but with a small magnitude and this bias decreases as the number of years (clusters) increases (Petersen, 2009). Therefore column 2 in Table 4 reports the results of clustered standard errors by time for fixed effect estimations.

In the presence of both time effect and country effect, without specifying the form of dependence, the standard errors clustered by country and time produce unbiased estimate of the true standard errors, assuming the number of clusters is sufficient (Petersen, 2009). Column 3 in Table 4 reports the results of clustered errors by country and year for the fixed effect estimation. Regardless of the estimated corrected standard errors the results remain qualitatively unchanged, i.e., green growth factors have a significant negative relationship with future aggregate stock market returns in European stock markets.

6. Conclusion

Sustainable development can be achieved by adopting a green economy. Therefore, this paper addresses this important issue by investigating whether stock investors in the European stock market have realized the importance of green growth to achieve sustainable development goals and growth. To the best of the researchers' knowledge, this is the first attempt to examine the impact of aggregate green growth indicators on future aggregate stock market returns. Green growth indicators can be seen as potential risk factors that capture the changes in investor's future investment opportunity set.

The results show investors in the European stock market are valuing green growth. We find that the higher the energy productivity, the lower the return on aggregate stock market and similarly, the higher the feed-in tariff for solar PV electricity generation, the lower the future aggregate stock market returns. These findings are consistent with the theoretical arguments of Feldman et al. (1997) reduction in risk perceived by investors and the shunned stock hypothesis.

The findings of the paper have important policy implications. It shows that economic policies are key drivers of green growth and sustainable development, especially those related to energy sector. This is important finding for all countries across the glove to direct them in their endeavor to achieve sustainable development goals.

The paper also addresses the econometric problems of residual correlation across countries and across time that panel data may suffer from. We run a battery of tests to correct standard errors and hence make sure that the results are not affected by such a problem. The results of the paper remain robust to the estimation method and the type of corrected standard errors.

Future research could be carried out on a country-by-country basis to see whether the results differ between countries. Furthermore, it would be interesting to include forecasting for multiple years rather than one year and also examine the impact of green growth policies in emerging stock markets.

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Ethical Statement

if your paper includes the research on animal and human subjects under the Bioethics Act. (Option 1, This paper has received the approval of OOO University, Ethical Statement/Approval on 0000-00-00(date)). (Option 2, Ethical review and approval were waived for this study, because…..(reason)). (Option 3, Not applicable because this research does not include animals or human subjects, it uses secondary data that is available for public).

CRediT authorship contribution statement

Diana Abu-Ghunmi: methodology and writing. **Lina Abu-Ghunmi**: data and methodology. **Basheer Ahmad Khamees**: Formal anlysis, Writing - original draft; **Keith Anderson**: Formal analysis, Writing-review & editing; **Mohammad Abu Gunmi**: Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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