Performance and Factor Structure of Green, Grey and Red Securities

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Green, Grey & Red Securities

Green (eco-friendly) securities are those where the primary business is relatively beneficial to the environment. Green stocks are likely to be concentrated in areas such as alternative energy, pollution control, carbon abatement and recycling.

Red/Brown (eco-enemy) securities are harmful to the environment.

Grey (not eco-friendly and not eco-enemy) securities are not harmful but also not beneficial.

Categorization is sometimes ambiguous. Even though the institutions have a different type of sector classification, the greatest problem is figuring out if the company's business activity is ('really') beneficial for the environment.

Green, Grey & Red Securities

Contentious	Grey	Brown	Green
Gas-fired power, bioenergy, hydropower, nuclear power		Fossil fuels	Solar, wind
Energy efficiency without credentials/standards or from the perspective of fossil fuels or at risk of "rebound effect"			Energy efficiency
	Agri-food		
	Real estate		
	Forestry		
Waste management			Recycling, composting
	Transport		Electric and alternative mobility
	ICT		

Source: Kepler Cheuvreux, CBI, FTSE, MSCI

SASB Industry Classification	Crunchbase Classification	Paper Terminology
Renewable Resources, Alternative Energy & Infrastructure (Utilities and Waste Management).	Battery, Biofuel, Biomass Energy, Clean Energy, CleanTech, Electric Vehicle, Electrical Distribution, Energy Efficiency, Energy Management, Energy Storage, Environmental Consulting, Environmental Engineering, Fuel Cell, Green Building, Green Consumer Goods, GreenTech, Paper Manufacturing, Pollution Control, Power Grid, Renewable Energy, Smart Building, Smart Home, Solar, Sustainability, Timber, Waste Management, Water, Water Purification, Water Transportation, Wind Energy, Wood Processing, Recycling	Green
Non-Renewable Resources	Fossil Fuels, Fuel, Mineral, Mining Technology, Natural Resources, Oil and Gas, Precious Metals, Mining	Brown
Healthcare, Financials, Technology and Communications, Transportation, Services, Consumption, Infrastructure (Infrastructure and Real Estate).	Software, Biotech, Healthcare, Telecommunications, Real Estate and other sectors excluding the ones above.	Gray

Source: SASB, Research paper

Research Objectives

1. Determine the factors that influence performance over time, before and after the EU financial crisis, which in our analysis pick as the break point the year 2009 (Nelson et al., 2012)

2. Study the macro factor exposure on Green, Grey and Red asset returns

3. Compare the performance of Green and Red assets

Research Elaboration

Previous research (e.g. Gbenga Ibikunle, 2015; Yaşar Erdinç, 2018; Stephen Brammer, 2009; Guillermo Badía, 2018, etc.) focuses on the performance of the portfolios or funds which include Green and Red stocks or just Green or assets with different act of green process.

This research contributes to closing a gap in the literature and seeks to find the relationship between Green and Red security returns and also study the macro factor exposure of the Green, Grey and Red securities.

Data Sources

- The stocks are from 28 Eurozone countries (with UK).
- The sample period is 2000 – 2019 and the sub-period we are studying is divided into ex-ante and ex-post 2009 Eurozone crisis (2000 – 2009 and 2010 – 2019).
- The source of the data is datastream and library of Keneth Fama French.
- The data set contains 1623 Grey, 125 Green and 258 Red stocks which are identified by renown institutions (and investment companies) as Kepler Cheuvreux, CBI, FTSE, MSCI and SASB (see Table 1).

Data Transformation

In the returns apply the winsorization method (at 99%), in which conversion on the data aims to limit the extreme values within the sample and to reduce the effect of possibly spurious outliers.

The prices of the stocks are observed daily but aggregated to monthly frequency and the returns are in two forms: i) simple returns and ii) log-returns

The approximation (in the equation 1) happens in the case for the very small values in the returns. Most common is when the durations of the trade is for short holding period, then the following approximation ensures the value for the log-returns are close in value with raw returns.

$$r_{i,t}^{e\prime} = \ln(1+ r_{i,t}^{e}) \approx r_{i,t}^{e} \quad \text{(eq. 1)}$$

Data Transformation

The first type of aggregation in monthly data for simple returns is defined as:

$$r_{i,t}^{j} = \left(\frac{P_{i,t_2} - P_{i,t_1}}{P_{i,t_1}} + 1\right) \ldots \ldots \left(\frac{P_{i,t_2} - P_{i,t_2}}{P_{i,t_2}} + 1\right) - 1 = \frac{P_{i,t_2}}{P_{i,t_1}} * \frac{P_{i,t_3}}{P_{i,t_2}} * \cdots * \frac{P_{i,t_k}}{P_{i,t_{k-1}}} - 1 = \frac{P_{i,t_k}}{P_{i,t_1}} - 1$$

The second type of aggregation in monthly data for log-returns is defined as:

$$r_{i,t}^{j'} = r_t[k] = r_t + r_{t-1} + \cdots + r_{t-k+1} = \ln\left(\frac{P_{i,t_2}}{P_{i,t_1}} * \frac{P_{i,t_3}}{P_{i,t_2}} * \cdots * \frac{P_{i,t_k}}{P_{i,t_{k-1}}}\right) = \ln\left(\frac{P_{i,t_2}}{P_{i,t_1}}\right) + \ln\left(\frac{P_{i,t_3}}{P_{i,t_2}}\right) + \cdots + \ln\left(\frac{P_{i,t_k}}{P_{i,t_{k-1}}}\right) = \ln\left(\frac{P_{i,t_k}}{P_{i,t_1}}\right)$$

with $P_{i,t}$ denote the stock price and the index (i) is the specific-stock and the other one is for the period, which is noted t_1 = the first day of the month, and t_k = the last day of the month.

Methodology

Our methods are based on two approaches:

1) the panel data model with random effect[1], which take into consideration the individual class of securities heterogeneity (Cameron, 2009) and

2) a combination of the time series model and continues with the cross-sectional model to capture the differentiation between the green and red assets.

As we mentioned in the previous slide, we standardize the returns with the winsorization method. One reason we have extreme values is owning small, isolated illiquid securities in the market, that can cause aggressive movement in the securities returns within the financial market and with the effect of the financial crisis that made the effect intense for these securities.

[1]Note: the factors are repeated observations for every security, and the securities are belonging in the similar activity sector with large number in the cross-section regression

Model Specification I

Below are illustrated the hybrid models from Fama-French (1993; 2015) and Carhart Model (1997)for every asset class:

$$r_{i,t}^{j} - r_{f,t} = a_i + b_{1,i}^{j} MKTRF_t + b_{2,i}^{j} SMB_t + b_{3,i}^{j} HML_t + e_{i,t}^{j} \quad [1]$$

$$r_{i,t}^{j} - r_{f,t} = a_i + b_{1,i}^{j} MKTRF_t + b_{2,i}^{j} SMB_t + b_{3,i}^{j} HML_t + b_{4,i}^{j} MOM_t + e_{i,t}^{j} \quad [2]$$

$$r_{i,t}^{j} - r_{f,t} = a_i + b_{1,i}^{j} MKTRF_t + b_{2,i}^{j} SMB_t + b_{3,i}^{j} HML_t + b_{4,i}^{j} RMW_t + b_{5,i}^{j} CMA_t + e_{i,t}^{j} \quad [3]$$

with i = 1, …, n securities, t = 1, …, T (1/2000 – 12/2019) and j = the asset class (Green, Grey or Red)
The first 3 models are estimated by panel data with random effect.

Where:

MKTRF = $r_{m,t} - r_{f,t}$; SMB = return spread of small minus large stocks; HML = return spread of cheap minus expensive stocks; MOM = monthly momentum; RMW = Robust Minus Weak;
CMA = conservative minus aggressive

Model Specification II

The 4th model construct from two-step approach (extension from Fama and MacBeth, 1973):

1st Step:

For each asset (i) estimate the alphas with FFM and CM in a time series (TS) regression

2nd Step:

I used the alpha as a dependent variable in a cross-sectional (CS) regression with the Green dummy:

$$a_i = c + b_1 D_i + u_i \text{ , with } D_i = \begin{cases} 1, i = Green\ asset \\ 0, i = Red\ /\ Brown\ asset \end{cases} \quad [4]$$

In order to implement the second regression, first, we perform the time-series regressions for each individual asset without the Green dummy variable . We then take the first step alphas from this set of time series regressions and perform cross-sectional regressions of these cross-sectional alphas on the dummy, for each time period individually. This gives the exposure of the Green factor return and is estimated by b_1.

Empirical Results and Findings

Table 1

Period	Green Ret.	Model	Alpha	MktRf	SMB	HML	MOM	RMW	CMA	R-sq within	R-sq between	R-sq overall
2000 – 2009	*Simple*	[1]	-.1704	.5975	.3897	.0087				7.34%	6.33%	7.31%
		[2]	-.6256	.5713	.4065	-.0148	-.0583			7.38%	5.98%	7.34%
		[3]	-.0459	.5267	.3372	.1414		-.0656	-.3279	7.47%	5.99%	7.43%
	Log	[1]	-.8737	.6187	.3723	-.0104				8.54%	1.67%	8.47%
		[2]	-.8266	.5922	.3893	-.0341	-.059			8.58%	1.6%	8.51%
		[3]	-.7493	.5506	.3229	.112		-.075	-.3104	8.67%	1.95%	8.59%
2010 – 2019	*Simple*	[1]	-1.021	.5658	.4151	.1238				7.93%	26.30%	7.74%
		[2]	-.9436	.5588	.4173	.0897	-.0759			7.96%	27.52%	7,78%
		[3]	-.9207	.5453	.3914	.1969		-.0417	-.2674	7.98%	27.20%	7.80%
	Log	[1]	-1.4976	.5769	.4083	.1323				8.02%	21.89%	7.74%
		[2]	-1.4107	.5707	0.41	.1029	-.0661			8.04%	23.53%	7.77%
		[3]	-1.4393	.5565	.382	.1847		-.0728	-.2612	8.07%	22.87%	7.79%
2000 – 2019	*Simple*	[1]	-.7224	.5959	.4019	.0839				8.33%	15.13%	8.29%
		[2]	-.6256	.5748	.4138	.0564	-.0743			8.38%	13.82%	8.34%
		[3]	-.6122	.5466	.3591	.2003		-.05	-.3136	8.43%	16.21%	8.40%
	Log	[1]	-1.2777	.6096	.3961	.0715				8.92%	4.62%	8.82%
		[2]	-1.1748	.5878	.408	.0423	-.0771			8.89%	3.48%	8.87%
		[3]	-1.1505	.5574	.3511	.1815		-.0759	-.323	9.04%	5.49%	8.94%

Table 2

Period	Red Ret.	Model	Alpha	MktRf	SMB	HML	MOM	RMW	CMA	R-sq within	R-sq between	R-sq overall
2000 – 2009	*Simple*	[1]	-.3854	.4882	.478	.0048				13.1%	10.94%	12.93%
		[2]	-.3841	.487	.4788	.0036	-.0027			13.1%	10.94%	12.93%
		[3]	-.4354	.4328	.4031	.2743		.3122	-.4138	13.86%	10.5%	13.67%
	Log	[1]	-.8804	.495	.4785	.0153				12.35%	8.83%	12.06%
		[2]	-.8843	.497	.4771	.0173	.0048			12.35%	8.84%	12.06%
		[3]	-.926	.4362	.4003	.2958		.3185	-.434	13.10%	8.27%	12.77%
2010 – 2019	*Simple*	[1]	-.6703	.5487	-.0484	.2556				9.24%	0.65%	9.04%
		[2]	-.6005	.5426	-.047	.2269	-.0634			9.26%	0.84%	9.06%
		[3]	-.6972	.5325	-.0471	.4726		.2301	-.2527	9.33%	0.87%	9.13%
	Log	[1]	-1.2514	.5526	-.0391	.2581				9.19%	0.3%	8.87%
		[2]	-1.1959	.5468	-.0378	.2304	-.0611			9.21%	0.35%	8.9%
		[3]	-1.29	.5377	-.0369	.4662		.2261	-.2343	9.28%	0.46%	8.96%
2000 – 2019	*Simple*	[1]	-.7671	.5329	.2704	.1589				10.76%	0.16%	10.63%
		[2]	-.759	.5308	.2717	.1558	-.008			10.76%	0.16%	10.63%
		[3]	-.8088	.4956	.2289	.4279		.2792	-.3713	11.11%	0.28%	10.99%
	Log	[1]	-1.22	.5421	.2806	.1624				10.63%	6.75%	10.45%
		[2]	-1.2193	.5418	.2807	.162	-.0009			10.63%	6.75%	10.45%
		[3]	-1.2644	.5027	.2369	.4438		.29	-.3904	10.99%	6.61%	10.83%

Empirical Results and Findings

Table 3

Period	Grey Ret.	Model	Alpha	MktRf	SMB	HML	MOM	RMW	CMA	R-sq within	R-sq between	R-sq overall
2000 – 2009	*Simple*	[1]	**-.7135**	**.6229**	**.4123**	**-.3259**				10.47%	10.75%	10.40%
		[2]	**-.5185**	**.5248**	**.4951**	**-.4025**	**-.2209**			11.17%	10.34%	11.10%
		[3]	**-.3127**	**.489**	**.3799**	**-.2929**		**-.6447**	**-.3665**	11.37%	11.09%	11.29%
	Log	[1]	**-1.2233**	**.6418**	**.4127**	**-.352**				10.93%	10.33%	10.8%
		[2]	**-1.0317**	**.5436**	**.4955**	**-.4291**	**-.2211**			11.61%	10.51%	11.49%
		[3]	**-.8123**	**.5037**	**.3782**	**-.3125**		**-.6533**	**-.384**	11.85%	10.92%	11.72%
2010 – 2019	*Simple*	[1]	-.0073	**.4639**	**.214**	**-.0646**				6.41%	0.14%	6.27%
		[2]	.0341	**.4594**	**.2152**	**-.0837**	**-.0429**			6.43%	0.18%	6.29%
		[3]	-.0019	**.4568**	**.208**	-.0209		.0184	**-.0931**	6.41%	0.14%	6.27%
	Log	[1]	**-.303**	**.4643**	**.2179**	**-.0639**				6.46%	0.12%	6.29%
		[2]	**-.2618**	**.4599**	**.2191**	**-.083**	**-.043**			6.48%	0.16%	6.3%
		[3]	**-.296**	**0.457**	**.2111**	-.0237		.0108	**-.0951**	6.47%	0.13%	6.30%
2000 – 2019	*Simple*	[1]	**-.4025**	**.5598**	**.3347**	**-.2369**				8.72%	9.75%	8.68%
		[2]	**.2525**	**.5125**	**.3712**	**-.2898**	**-.1608**			9.07%	10.61%	9.03%
		[3]	**-.1484**	**.4807**	**.2877**	**-.2405**		**-.422**	**-.3188**	9.19%	12.33%	9.16%
	Log	[1]	**-.7624**	**.567**	**.3358**	**-.2472**				8.98%	10.02%	8.92%
		[2]	**-.6136**	**.5198**	**.3721**	**-.3**	**-.1601**			9.33%	10.91%	9.27%
		[3]	**-.5046**	**.4856**	**.2872**	**-.249**		**-.4308**	**-.3304**	9.48%	12.54%	9.43%

The tables 1-3 show the alpha and beta value of the MktRf, SMB, HML, MOM, RMW and CMA factor from the random effect regression (after Winsorization). The global factors are collected from the Kenneth R. French data library. Additionally, the results report both dependent variables that are the simple returns and the log returns. We denote the models 1, 2 and 3; the 3 Factor-Fama and French Model, 4 Factor Carhart Model and 5 Factor Fama-French Model, respectively. The table reports the results from equation [1] till [3]. The last 3 columns are the R squared for within, between and overall. Numbers in bold are significantly greater than zero with 95% confidence. The results are expressed as percentages (%) and round on 4th decimal.

Empirical Results and Findings

Table 4

Alpha performance of Green VS Red securities									
Time	2000 – 2009			2010 – 2019			2000 – 2019		
Model	3F -FFM	4F-CM	5F-FFM	3F -FFM	4F-CM	5F-FFM	3F -FFM	4F-CM	5F-FFM
Green Factor	-0.2547	-0.239	-0.057	-1.845**	-2.04**	-1.989**	-1.067*	-1.3215*	-1.37**

The first two rows describe the method which is the time series regression (TS) for every entity (asset returns), and therefore we specified the model and the period (monthly freq.). The last row is the factor exposure from the cross-sectional (CS) regression, the alphas with the dummy variable. The alpha is the risk-adjusted abnormal return relative to the applied proxies from FFM and CM. We denote as 3F-FFM – 3 Factor Fama French Model; 4F-CM – 4 Factor Carhart Model; 5F-FFM – 5 Factor Fama French Model and using the Kenneth R. French data library. The table reports the results from equation [7]. Additionally, we note beside the number with the star the significant level (*, ** and *** is corresponding to statistical significance at 10 %, 5 % and 1 % levels, respectively).

Conclusion

This research examines the risk sensitivities of EU Green, Grey and Red securities and the performance of Green vis-à-vis Red securities over time.

As mentioned before, a Red asset return is an implicit return associated with the equity returns of environmentally-unfriendly companies and conversely, a Green asset return is an implicit return associated with environmentally-friendly equities.

1. These findings underscore the intuition that Green, Red and Grey returns are influenced by various other economic and political factors, not properly captured by the standard equity index and the rest of the factors from FFM and CM (see results from *Tables 1-3).*
2. Every asset class underperforms compared to the market index benchmark and the exposure on the rest of the factors (or 'anomalies'), that is showing promising results for explaining the risk-adjusted returns.
3. The Red securities are overperforming the Green securities. That implies in practice, investors can enhance their exposure to eco-enemy investments with sustaining a gain in risk-adjusted returns (Ito, 2013).

Applications

Our research identifies a different investment process on the way of building a portfolio, implementing strategies, and measuring the performance among our asset classes. As we mentioned, we use a special classification standard that has a detailed classification including the three distinct groups the Green, Red, and Grey. The group of factors, explore the strategies for portfolio construction. This research gives insight on:

1. investment strategies that have less exposure to green securities (or differentiate their strategies e.g. with short positions for Green and long positions for Red).
2. investors/firms understand the risk exposure on the green, grey and red securities
3. portfolio management and allocation of the Green & Red assets
4. Manage risk-return

Limitations

All studies have limitations which should restudy because that may influence outcomes and conclusions from our research.

- Observe strong correlation between the market factor and the risk factors (the 'anomalies' factor called also as systemic factors which are affected from the market)
- In our analysis the relationships hold between security returns and risk factors that had been observed in the past could not be expected to continue to hold in the future (covid 19 situation).
- The results from the first subperiod is different from the second subperiod that shows it is possible for a misleading outcome and a mispricing story by the market for the later years. (the economic environment)
- The results are based on stocks within the European markets and are affected by the EU policies
- In our models, we require a liquid market, which is reflected in the securities' returns. However, in some rare cases, we have access to illiquid securities on which we applied the transformation method for revealing the impact of the factors.

Despite the limitations of this study, the findings of this research demand attention.

For Future Research…

- This research can be extended in two dimensions, time and geographic.
- Furthermore, we can link new explanatory factors in the model that will enhance the explanation of the performance and the differences in the factor structure of the Green, Grey and Red securities:

1. Environmental, Social, Government (ESG) (Kelly van Heijningen, 2019) scores or Social Responsible Investing (SRI) (Mollet, Janick Christian et al., 2014; Stewart Jones et al., 2008) or Corporate Social Responsibility (CSR) (Benjamin Hübel et al., 2018; Kais Bouslah et al., 2012; MEIR STATMAN et al., 2016) ratings in Green and Red stocks. Another research paper construct a specific factor, the greenness factor (Alessi Lucia,2019):

   $G_{i,y} = ESG_{i,y} \frac{Sales_{i,y}}{Emissions_{i,y}}$

2. Additionally, we can use the factors of the quality (QLY) (Asness et al., 2013) and liquidity (LIQ) (Pastor & Stambaugh, 2003) in our models.

3. Semi-factor structure in Green, Red and Grey securities (Gregory Connor et al., 2019)

All these factors can get additional exposure beta beyond our models and a combination of signals (factors) may sharpen the view of the performance and factor exposure.

Bibliography

- Alberta DiGiuli, L. K. (2014). "Are red or blue companies more likely to go green? Politics and corporate social responsibility." Journal of Financial Economics 111(1): 158-180.
- Asness, C.S., Frazzini, A. & Pedersen L.H. (2013). Quality Minus Junk. Working paper, AQR Capital Management.
- Bouslah, K., et al. (2013). "The impact of the dimensions of social performance on firm risk." Journal of Banking & Finance 37(4): 1258-1273.
- Brammer, S., et al. (2005). "The Stock Performance of America's 100 Best Corporate Citizens." SSRN Electronic Journal.
- Carhart, M. M. (1997). On persistence in mutual fund performance. The Journal of Finance, 52(1), 57-82.
- Cojoianu, T., et al. (2018). "Going from Zero to One: How Environmental Knowledge and Policy Shapes Start-Up Creation across Green, Brown and Gray Industries." SSRN Electronic Journal.
- Connor, G. and R. Korajczyk (2019). "Semi-strong Factors in Asset Returns." SSRN Electronic Journal.
- Eugene F. Fama, K. R. F. (2008). "Average Returns, B/M, and Share Issues." The Journal of Finance 63(6): 2971-2995.

Bibliography

- Eugene F. Fama, K. R. F. (2015). "A five-factor asset pricing model." Journal of Financial Economics 116(1): 1-22.
- Fama, E. F. and K. R. French (1993). "Common risk factors in the returns on stocks and bonds." Journal of Financial Economics 33(1): 3-5
- Fama, E. F. and K. R. French (1998). "Value versus Growth: The International Evidence." The Journal of Finance 53(6): 1975-1999.
- Fama, E. F. and K. R. French (2012). "Size, value, and momentum in international stock returns." Journal of Financial Economics 105(3): 457-472.
- Gbenga Ibikunle, T. S. (2015). "European Green Mutual Fund Performance: A Comparative Analysis with their Conventional and Black Peers." Journal of Business Ethics 145: 337–355.
- Guillermo Badia, L. F., Maria Ceu Cortez (2019). "The performance of socially responsible stock portfolios: international evidence." EFMA European Financial Management Association 2019 Annual Meeting, Azores. Retrieved.
- Heijningen, K. v. (2019). "The impact of ESG factor materiality on stock performance of firms."
- Hübel, B., et al. (2018). Stocks without sustainability rating: Characteristics and performance impact on socially responsible portfolio

Bibliography

- Lucia, A., et al. (2019). The Greenium Matters: Evidence on the Pricing of Climate Risk. JRC Working Papers in Economics and Finance. Luxembourg: 29.
- Mollet, J. C. and A. Ziegler (2014). "Socially responsible investing and stock performance: New empirical evidence for the US and European stock markets." Review of Financial Economics 23(4): 208-216.
- Pástor, Ľ., & Stambaugh, R. F. (2003). Liquidity risk and expected stock returns. Journal of Political economy, 111(3), 642-685
- Porter Michael, V. d. L. C. (1995). "Toward a new conception of the environment-competitiveness relationship." Journal of Economic Perspective 9(4): 97-118.
- Statman, M. and D. Glushkov (2016). "Classifying and Measuring the Performance of Socially Responsible Mutual Funds." The Journal of Portfolio Management 42: 140-151.
- Stefan Ambec, P. L. (2008). "Does It Pay to Be Green? A Systematic Overview." Academy of Management Perspectives 22(4): 45-62.
- Stewart Jones, S. v. d. L., Geoff Frost, Janice Loftus (2008). "The Investment Performance of Socially Responsible Investment Funds in Australia." Journal of Business Ethics 80(2): 181-203.
- Turan G. Bali, N. C., Frank J. Fabozzi (2012). "Book-to-Market and the Cross-Section of Expected Returns in International Stock Markets." The Journal of Portfolio Management 39(2): 101-115.
- Yaşar, E. (2018). "Comparison of CAPM, Three-Factor Fama-French Model and Five-Factor Fama-French Model for the Turkish Stock Market."

THANK YOU

For your attention!