POLITECNICO MILANO 1863

SCUOLA DI INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE

Executive Summary of the Thesis

Integrating ESG factors into Capital Asset Pricing Model: ESG uncertainties and ESG betas

Laurea Magistrale in Mathematical Engineering - Ingegneria Matematica

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Academic year: 2022-2023

1. Introduction

In recent years, sustainable investments have assumed a crucial role in portfolio selections, indicating a significant evolution in investment strategies. Increased awareness of global challenges related to the environment, social issues, and corporate governance prompts a recalibration of evaluation criteria, with investors integrating ESG (Environmental, Social, Governance) principles alongside traditional financial metrics. The ESG score, providing a comprehensive and weighted assessment of the three pillars, stands as the preeminent metric favored by investors.

Several capital asset pricing models that consider ESG implications have been developed in the literature. Consistent with the model presented by Pastor et al. (2021) [5], Avramov et al. (2022) [1] derive a model in which the equilibrium expected returns depend on (1) the market risk factor and (2) an ESG-based factor. Moreover, they propose another model in which they consider an ESG uncertainty factor, which is the uncertainty related to the corporate ESG profile. Indeed, all ESG rating providers produce an ESG rating with proprietary and black-box methodologies, as also reported by Del Vitto et al. (2023) [3]. This creates discrepancies between the different ratings in the market. However, we find no significant evidence of uncertainty within ESG data. Thus we claim that no additional factor is needed in the asset pricing model to account for ESG uncertainty.

This thesis wants to contribute to the existing literature by performing an empirical evaluation of the model presented by Avramov et al. (2022) [1] on market data and investigating whether an additional uncertainty factor is necessary for the CAPM.

In particular, we build a comprehensive dataset of ESG and returns data of US stocks retrieved from Refinitiv. Then, in the first part of the thesis, we calibrate the model presented by Avramov et al. (2022) [1] which does not consider the uncertainty factor and we find no statistical evidence that stock returns depend on uncertainty. Moreover, performing a cross-sectional regression on the coefficient values estimated in the regression model, we find no statistical evidence of an ESG risk premium both for the ESG portfolio factor and the ESG market factor. In the second part of the thesis, observing that the market ESG score is not very informative in the model, we estimate a simpler regression model in which the stock returns do not depend on the average market ESG score. In this case, the cross-sectional regression shows that stocks are subject to a negative ESG premium.

2. ESG CAPM

We focus on the model presented by Avramov et al. (2022) [1] to model the equilibrium expected returns of the risky assets when no ESG uncertainty is taken into account

$$\mu_r = \beta\mu_M - b_M\mu_g + b_M\beta\mu_{g,M} \quad (1)$$

where β is the equilibrium CAPM beta, μ_M is the equilibrium market premium, b_M is the aggregate brown aversion, μ_g is the expected ESG score and $\mu_{g,M}$ is the aggregate market greenness.

We initially disregard the dependence between the coefficients in the model and reformulate (1) into a general three-factor regression model

$$\mu_r = \alpha + \beta_1\mu_m + \beta_2\mu_g + \beta_3\mu_{g,m} + \epsilon \quad (2)$$

where $\beta_1 = \beta$, $\beta_2 = -b_M$ and $\beta_3 = b_M\beta$ and ϵ is an error term.
Then, we perform some statistical tests to investigate the relationships in the model (1).

3. Model Estimation

In order to implement our analysis, we construct a comprehensive dataset of ESG scores and financial data collected from Refinitiv. We focus on the components of the Russell3000 index from 2017 to 2022. Moreover, we perform a preprocessing of the data. In particular, as we observed volatility spikes in market returns during the reporting period, we performed a 95% winsorization on returns data.

Following the approach of Brennan et al. (2008) [2], we perform a first calibration of the regression model (2) on each stock to estimate β_1, β_2 and β_3 and we divide the stocks into 27 portfolios based on the β values found. We then estimate the other factors in the model by weighting the stock data by their market capitalization value.

We fit the linear regression model (2). The results obtained in this first calibration do not statistically support the assumptions of the model presented by Avramov et al. (2022) [1]. In particular, we observe that the positive dependence of expected portfolio returns on the market factor is verified in all portfolios, instead the dependence of expected portfolio returns on ESG factors is not verified in all portfolios. Indeed, we observe that β_2 is not very significant and its sign does not confirm the negative dependence of expected portfolio returns on portfolio ESG score in all portfolios, as predicted by (1). Similarly, β_3 is not very significant and its sign does not confirm the positive dependence of expected portfolio returns on market ESG score in all portfolios. We perform a robustness check and we find that the results are robust controlling for firm characteristics presented in Fama et al. (1993) [4].

3.1. Regression analysis with MLE method and LR test

The regression analysis calibrated on the collected data does not yield significant results to support the model presented by Avramov et al. (2022) [1]. In particular, nothing explicit emerges regarding the dependence of coefficient β_3 on β_1 and β_2. Therefore, to test this hypothesis, we proceed with a statistical test based on the maximum likelihood estimation method. We consider the Log-Likelihood function of the normal distribution and we define two different Log-Likelihood functions for the two different sets of parameters. In particular, we define $L_1(\beta_1, \beta_2, \beta_3)$ for the general model which does not consider the dependence between coefficients and $L_2(\beta_1, \beta_2, -\beta_1\beta_2)$ for the model which considers the dependence between coefficients presented in (2). Finally, we perform the likelihood-ratio test on the Log-Likelihood values found.

The test shows that we reject the null hypothesis of dependency between parameters at a 10% significance level in only 11 out of 27 portfolios. Therefore, we verify the assumption of the model and we can also argue that there is no evidence of uncertainty in the model.

3.2. Regression on beta coefficients

To further analyze the positive or negative dependence of asset returns on portfolio and market ESG score we perform a cross-section regression as follows

$$\mu_r = \lambda_0 + \lambda_1\beta_1 + \lambda_2\beta_2 + \lambda_3\beta_3 \tag{3}$$

where the β values are from the first stage regression performed in section 3.

Table 1: Newey-West adjusted cross-sectional regression estimates of the model

$$\mu_r = \lambda_0 + \lambda_1\beta_1 + \lambda_2\beta_2 + \lambda_3\beta_3$$

where the β values are from the first stage regression

$$\mu_r = \alpha + \beta_1\mu_m + \beta_2\mu_g + \beta_3\mu_{g,m}$$

using MarketCap-weighted data.
Values with "°","*","**" and "***" are significant at the 10%, 5%, 1% and 0.1% levels, respectively.

λ_0	λ_1	λ_2	λ_3
0.73***	0.61***	-0.04	0.12

From the results shown in Table 1, we observe that the coefficients associated with ESG betas do not appear to be significant in the regression model. Thus, there is no relation between ESG betas and portfolio returns, which therefore does not support the idea of an ESG premium for portfolios.

4. ESG CAPM model excluding ESG market factor

The analysis performed in section 3 does not lead to significant results in support of the model presented by Avramov et al. (2022) [1]. However, during our analysis, we observe that the average ESG market score is a linear increasing function of time and thus it does not appear to be very informative in the asset pricing model. Therefore, given the results obtained in section 3, we propose a model that does not consider the market ESG score factor

$$\mu_r = \alpha + \beta_1\mu_m + \beta_2\mu_g \tag{4}$$

where $\beta_1 = \beta$ and $\beta_2 = -b_m$.
We suppose, as in the previous model, that there is a negative dependence of the expected excess asset returns on the ESG score of the asset. This assumption follows the idea that there is a negative risk premium associated with holding a green asset.

4.1. Regression analysis excluding ESG market factor

We perform a first calibration of the regression model (4) on the stocks of the Russell3000 index in the sample in order to estimate β_1 and β_2. We then divide the stocks into 9 portfolios depending on values of β_1 and β_2 found. We estimate the new parameters of the model following the same procedure of section 3 and we calibrate the model on the data. In Table 2, we report the results of the calibration performed with the OLS method.

Table 2: Newey-West adjusted estimates using MarkCap-weighted data for the regression model

$$\mu_r = \alpha + \beta_1\mu_m + \beta_2\mu_g$$

Values with "°","*","**" and "***" are significant at the 10%, 5%, 1% and 0.1% levels, respectively.

(a) α value

		β_2		
		Low	**Medium**	**High**
β_1	**Low**	0.46	-0.20	-0.75
	Medium	-2.21	0.92	-0.11
	High	2.99	1.78	-0.05

(b) β_1 value

		β_2		
		Low	**Medium**	**High**
β_1	**Low**	0.64***	0.59***	0.59***
	Medium	1.07***	1.01***	1.00***
	High	1.38***	1.28***	1.44***

(c) β_2 value

		β_2		
		Low	**Medium**	**High**
β_1	**Low**	-0.04	0.02	0.13°
	Medium	0.11	-0.03	0.08**
	High	-0.19	-0.05	0.17***

As expected, the market factor μ_m shows a 0.1% significance level and a positive dependence on expected portfolio returns in every portfolio.

The results are not as consistent in the case of the ESG portfolio factor μ_g. We observe that β_2 does not show a significant level in all portfolios. Moreover, we find that the cases where the coefficient β_2 is significant are those where β_2 is positive. Hence, we have no evidence of the negative dependence of the expected portfolio returns from the portfolio's ESG score.

4.2. Regression on beta coefficients excluding ESG market factor

We proceed in our analysis, as done in section 3, by performing a cross-sectional regression to investigate the presence of a negative ESG premium associated with the portfolio's ESG score.

We perform the cross-sectional regression

$$\mu_r = \lambda_0 + \lambda_1\beta_1 + \lambda_2\beta_2 \tag{5}$$

where the β values are from the first stage regression model (4). The regression summary statistics are shown in Table 3.

Table 3: Newey-West adjusted cross-sectional regression estimates of the model

$$\mu_r = \lambda_0 + \lambda_1\beta_1 + \lambda_2\beta_2$$

where the β values are from the first stage regression

$$\mu_r = \alpha + \beta_1\mu_m + \beta_2\mu_g$$

using MarketCap-weighted data.
Values with "°","*","**" and "***" are significant at the 10%, 5%, 1% and 0.1% levels, respectively.

λ_0	λ_1	λ_2
0.36*	0.37*	-3.19***

As expected, the results confirm the positive dependence of portfolio expected returns on market returns at 5% level. We also observe a negative dependence between portfolio expected returns and portfolio ESG beta at 0.1% significance level. We found in section 4.1 that in our sample when the coefficient β_2 is significant then it is also positive. The findings presented above support the assertion that if a stock demonstrates a positive correlation with its ESG score, it is associated with lower average returns compared to a stock exhibiting a negative correlation or no correlation with its ESG score.

The results obtained show that regardless of the ESG score value of some stocks, and thus whether the stock is "green" or "brown," these are subject to a negative ESG premium.

5. Conclusions

In this thesis, we conducted a comprehensive analysis of the impact of market ESG preferences on asset returns and examined the presence of an ESG risk premium, using a new comprehensive dataset of Russel 3000 stocks.

First, we find no statistical evidence that stock returns depend on uncertainty in the ESG profile of companies. Indeed, we calibrate the model of Avramov et al. (2022) [1] and perform a statistical test to understand whether market data are compatible with the no uncertainty case. Across the majority of portfolios, we do not have evidence to reject the null hypothesis of no impact of uncertainty in stock returns. This outcome reinforces the idea that market players are not affected by a perceived uncertainty in the ratings.

Second, we discuss how in the model of Avramov et al. (2022) [1] with no uncertainty there is no statistical evidence supporting the existence of an ESG risk premium, both in terms of the ESG portfolio factor and the ESG market factor. In particular, we conduct a cross-sectional regression on the coefficient values estimated in the regression model and find no relationship between ESG betas and stock returns.

Finally, we present a simplified regression model in which stock returns are assumed to be independent of the average market ESG score (4). In this case, the cross-sectional regression shows that stocks are subject to a negative ESG premium. This phenomenon can be explained because, in recent years, many investors have been using ESG ratings in their investment strategies. This means that a lot of investors are now relying on the ESG score when investing in a particular stock, and this, in turn, affects the stock's returns.

References

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