Do investors care about carbon risk?

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➢ 摘要

1. We study whether carbon emissions affect the cross-section of US stock returns. We find that stocks of firms with higher total carbon dioxide emissions (and changes in emissions) earn higher returns, controlling for size, book-to-market, and other return predictors.
2. We cannot explain this carbon premium through differences in unexpected profitability or other known risk factors。
3. We also find that institutional investors implement exclusionary screening based on direct emission intensity (the ratio of total emissions to sales) in a few salient industries.
4. Overall, our results are consistent with an interpretation that investors are already demanding compensation for their exposure to carbon emission risk.

➢ 碳溢价

在控制规模、账面市值比、动量等其他公认的预测回报的变量以及公司特征之后，碳排放量较高的公司仍然会有更高的股票回报。这种**更高碳排放带来更高股票回报的现象称为碳溢价**。

➢研究目的

本文通过研究股票回报如何随公司和行业的碳排放量变化而变化，来系统地探讨投资者是否要求碳风险溢价。

➢ Introduction引言

Many studies seek to explain the cross-sectional pattern of stock returns based on exposures to aggregate risk factors such as size and book-to-market ratios, or firmspecific risk linked to observable firm characteristics. **One variable that has so far been missing from the analysis is corporate carbon emissions.**

The lack of consensus among institutional investors around climate change naturally raises the possibility that **carbon risk may not yet be reflected in asset prices. To find out, in this paper** we systematically explore whether **investors demand a carbon risk premium** by looking at how stock returns vary with CO2 emissions across firms and industries.We undertake a standard cross-sectional analysis, **asking whether carbon emissions affect cross-sectional US stock returns.**

One Our study is related to a rapidly growing literature on **climate change and financial markets.**

➢ Introduction引言

研究背景

关于公司和行业的碳排放如何影响股票回报，作者提出以下三个假设：

1. **碳风险溢价假设：**碳排放过高的公司可能面临碳定价风险和其他限制排放的监管干预措施，而且对化石能源依赖程度高的公司也更容易受到低成本可再生能源技术风险的影响。因此，前瞻性投资者可能会要求碳风险溢价，从而导致公司碳排放与其股票回报之间具有正相关关系。
2. **碳α假设（市场无效率假设）：**金融市场对碳风险的定价效率低下，与碳排放相关的风险被低估了。大多数投资者可能没有完全考虑到碳风险。
3. **撤资假设：**高碳排放企业的股票与其他“罪恶股票”一样，被具有社会责任感的投资者所撤资，因此这些企业被要求更高的股票回报。

➢ 数据与变量

1.数据

本文从**FactSet**数据库获取股票收益、公司基本面和机构所有权的数据，并从**Trucost**数据库获取企业碳排放和其他温室气体排放的信息。通过**ISIN**编码和公司名称的匹配，最终选取了**2005**年至**2017**年**3421**家公司的数据。

碳排放数据衡量指标为以下三个口径：

第一**(scope 1 emissions):**公司拥有或控制的机构一年内的直接排放量，包括生产过程中使用的化石燃料的所有排放。

第二**(Scope 2 emissions):**公司外购的热力、蒸汽和电力产生的排放。

第三**(Scope 3 emissions):**公司生产的其他间接排放（如采购材料、产品使用、废物处理、外包活动）等。该类排放又分为上游排放和下游排放。

第一类和第二类排放数据是广泛报道的，第三类排放用投入产出矩阵估计。

➢ 数据与变量

1.数据

三种不同的企业碳排放指标：

第一，总排放水平（**the total level of emissions**）

第二，排放的逐年变化（**the year-by-yearchangeinemissions**）

第三，排放强度（**emission intensity,which measures carbon emissions per unit of sales.**）

2.变量描述

面板A:碳排放变量

Variable	Mean	Median	Std. Dev.
Panel A: Emission variables			
Log (Carbon Emissions Scope 1 (tons CO_2e))	10.55	10.47	2.95
Log (Carbon Emissions Scope 2 (tons CO_2e))	10.52	10.66	2.36
Log (Carbon Emissions Scope 3 (tons CO_2e))	12.31	12.46	2.25
Growth Rate in Carbon Emissions Scope 1 (winsorized at 2.5%)	0.08	0.03	0.36
Growth Rate in Carbon Emissions Scope 2 (winsorized at 2.5%)	0.14	0.05	0.45
Growth Rate in Carbon Emissions Scope 3 (winsorized at 2.5%)	0.09	0.06	0.24
Carbon Intensity Scope 1 (tons CO_2e/USD m.)/100 (winsorized at 2.5%)	1.92	0.15	5.88
Carbon Intensity Scope 2 (tons CO_2e/USD m.)/100 (winsorized at 2.5%)	0.34	0.18	0.46
Carbon Intensity Scope 3 (tons CO_2e/USD m.) /100 (winsorized at 2.5%)	1.58	0.98	1.59
Carbon Intensity Direct (winsorized at 2.5%)/100	2.12	0.16	6.45
Carbon Intensity Indirect (winsorized at 2.5%)/100	1.04	0.58	1.31
GHG Direct Impact Ratio (winsorized at 2.5%)	0.75	0.06	2.29
GHG Indirect Impact Ratio (winsorized at 2.5%)	0.71	0.47	0.68

2.变量描述

面板B:横截面收益变量　面板C:时间序列变量（因子变量）　面板D:所有权变量

Panel B: Cross-sectional return variables			
RET (%)	1.14	1.08	10.84
LOGSIZE	8.25	8.25	1.57
B/M (winsorized at 2.5%)	0.50	0.39	0.41
LEVERAGE (winsorized at 2.5%)	0.24	0.22	0.18
MOM (winsorized at 0.5%)	0.15	0.11	0.45
INVEST/A (winsorized at 2.5%)	0.05	0.03	0.05
ROE (winsorized at 2.5%, in%)	9.76	11.32	21.23
HHI	0.82	1.00	0.24
LOGPPE	6.22	6.34	2.26
BETA	1.10	1.05	0.44
VOLAT (winsorized at 0.5%)	0.10	0.08	0.06
SALESGR (winsorized at 0.5%)	0.02	0.03	0.30
EPSGR (winsorized at 0.5%)	0.01	0.00	0.43
Panel C: Time-series variables			
MKTRF (in%)	0.70	1.06	4.08
HML (in%)	0.00	−0.22	2.57
SMB (in%)	0.07	0.04	2.26
MOM (in%)	0.07	0.36	4.53
CMA (in%)	0.02	−0.06	1.39
BAB (in%)	0.49	0.74	2.66
LIQ (in%)	0.15	0.38	3.59
NET ISSUANCE (in%)	0.51	0.55	1.65
IDIO VOL (in%)	−0.18	0.03	5.27
Panel D: Ownership variables			
IO (in%)	76.84	82.93	22.22
IO_BANKS (in%)	0.10	0.07	0.16
IO_INSURANCE (in%)	0.35	0.13	3.11
IO_INVESTCOS. (in%)	18.19	18.37	8.64
IO_ADVISERS (in%)	43.94	46.11	15.39
IO_PENSIONS (in%)	3.40	3.51	2.31
IO_HFS (in%)	10.87	7.73	10.04
PRINV (winsorized at 0.5%)	0.05	0.03	0.11
VOLAT (winsorized at 0.5%)	0.10	0.08	0.06
VOLUME (in $million) (winsorized at 2.5%)	0.44	0.21	0.56
NASDAQ	0.30	0.00	0.46
SP500	0.37	0.00	0.48

横截面收益变量

RET(%)：个股的月度回报，为横截面收益回归中的因变量。

LOGSIZE（公司规模）：公司年末市值(股票价格乘以流通股)的自然对数。

B/M（账面市值比）：公司的账面价值除以年末市值。

LEVERAGE（杠杆率）：公司的账面杠杆=债务的账面价值除以资产的账面价值。

MOM：最近12个月股票的平均回报。

INVEST/A（资本支出）：公司的资本支出除以资产的账面价值。

ROE (in%)：股本回报利率——公司的年净收入除以股权价值。

HHI（业务集中度）：不同业务部门的赫芬达尔集中度指数。

LOGPPE（有形资产）：财产、厂房和设备的自然对数。

BETA：公司的市场贝塔系数，使用一年的日度数据计算。

VOLAT：基于过去12个月月度回报的标准差。

SALESGR（销售增长）：年度公司销售额的美元变化。

EPSGR（每股收益增长）：年度每股收益的美元变化。

时间序列变量（因子变量）

MKTRF（市场因子）：价值加权股票市场的月收益减去无风险利率

HML（价值因子）：投资组合多价值股和短成长股的月收益（是做多账面市值比高的股票、做空账面市值比低的股票的投资组合的月回报）

SMB(市值因子)：做多小盘股、做空大盘股组合的月收益

MOM（动量因子）:投资组合中12个月上涨的股票和12个月下跌的股票的月回报率

CMA（投资因子）:做多保守投资股票、做空激进投资股票的投资组合的月回报率

BAB(贝塔因子)：一个投资组合的月回报，在低beta的股票上做多，在高beta的股票上做空;

LIQ（流动性因子）：Pastor和Stambaugh的流动性因素

NET ISSUANCE（净发行因子）：净发行量是一个投资组合的月回报率，该投资组合即做多净发行量高的股票，做空净发行量低的股票

IDIO VOL（异质波动性因子）：做多低特质波动性股票、做空高特质波动性股票的投资组合的月回报

所有权变量

$IO_{i,t}$：在第t年末FactSet数据库中机构所持有的公司 i 股份的比例

IO：将各类机构在年底所持有的股份相加，然后除以年底的流通股数量

IO_BANKS：银行的所有权

IO_INSURANCE ：保险公司的所有权

IO_INVESTCOS.：投资公司(如共同基金)的所有权

IO_ADVISERS：所有权由独立投资顾问持有

IO_PENSIONS：养老基金的所有权

IO_HFS：对冲基金的所有权

PRINV：公司i在t年底的股价的倒数

VOLAT：是公司i在一年内每日股票收益的标准差

VOLUME：股票i在日历年t的平均每日交易量(以百万美元为单位);

NASDAQ：一个指标变量,如果股票i在第t年在纳斯达克上市，它等于1，否则为零;

SP500：一个指标变量,如果一只股票i在第t年是标准普尔500指数的一部分，它等于1，否则为0

➢ 实证结果

We begin our analysis by investigating the determinants of scope 1, scope 2, and scope 3 emissions. (首先：我们从调查碳排放的决定性因素进行分析。)

We then turn to the evaluation of the carbon return premium in the crosssection of stocks.（其次，我们在股票截面上对碳回报溢价进行的评估。）

We next explore the time-series properties of the cross-sectional carbon premium with respect to well-known risk factors.（然后，我们探讨截面碳溢价的时间序列特性与众所周知的风险因子的关系。）

Finally, we consider the divestment hypothesis by looking at institutional ownership patterns.（最后，我们通过研究机构所有权模式来考虑撤资假设。）

➢ 实证结果

1.碳排放的决定因素

因变量为碳排放的三个指标。公司变量包括公司规模(LOGSIZE)、账面市值比(B/M)、权益回报率(ROE)、杠杆率(LEVERAGE)、资本支出(INVEST/A)、业务集中度(HHI)、有形资产(LOGPPE)、销售增长(SALESGR)和每股收益增长(EPSGR)。

回归结果如表7所示，所有三类排放水平和排放变化都与LOGSIZE显著正相关，但第一类和第三类的排放强度与LOGSIZE呈弱负相关。排放水平还与B/M、LEVERAGE、LOGPPE、SALESGR和EPSGR显著正相关。INVEST/A高的公司的排放水平较低，但排放变化存在高增长。只有HHI和LOGPPE对排放强度有显著影响。

Table 7
Determinants of carbon emissions.

The sample period is 2005–2017. The dependent variables are natural logarithm of total emissions, percentage change in total emissions, and carbon intensity. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the firm level and year (in parentheses). All regressions include year-month fixed effects and industry-fixed effects. ***1% significance; **5% significance; *10% significance.

Variables	(1) LOG (SCOPE 1)	(2) LOG (SCOPE 2)	(3) LOG (SCOPE 3)	(4) ΔSCOPE 1	(5) ΔSCOPE 2	(6) ΔSCOPE 3	(7) SCOPE 1 INT	(8) SCOPE 2 INT	(9) SCOPE 3 INT
LOGSIZE	0.438***	0.571***	0.572***	0.026***	0.026***	0.027***	−0.118*	0.002	−0.021**
	(0.036)	(0.032)	(0.022)	(0.008)	(0.008)	(0.006)	(0.063)	(0.006)	(0.009)
B/M	0.464***	0.555***	0.562***	−0.033**	−0.038	−0.041**	−0.003	0.003	0.000
	(0.060)	(0.059)	(0.054)	(0.015)	(0.021)	(0.017)	(0.107)	(0.010)	(0.013)
ROE	0.006***	0.006***	0.007***	−0.002***	−0.002***	−0.001***	−0.002	−0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)	(0.000)
LEVERAGE	0.531**	0.625***	0.574***	0.026	0.010	0.019	0.364	0.002	−0.056*
	(0.196)	(0.188)	(0.162)	(0.020)	(0.030)	(0.023)	(0.230)	(0.030)	(0.030)
INVEST/A	−2.026***	−1.950***	−2.457***	0.676***	0.706***	0.530***	−0.586	−0.067	−0.446**
	(0.489)	(0.460)	(0.432)	(0.145)	(0.132)	(0.117)	(1.161)	(0.153)	(0.201)
HHI	−1.044***	−0.569***	−0.499***	0.014	−0.024	0.023**	−2.185***	0.009	−0.260***
	(0.119)	(0.081)	(0.063)	(0.021)	(0.024)	(0.008)	(0.497)	(0.030)	(0.062)
LOGPPE	0.376***	0.372***	0.317***	−0.033***	−0.034***	−0.030***	0.127***	0.025***	0.026***
	(0.036)	(0.037)	(0.023)	(0.005)	(0.006)	(0.006)	(0.042)	(0.007)	(0.007)
SALESGR	0.237***	0.190**	0.231**	0.311***	0.343***	0.320***	−0.085	−0.019**	0.010
	(0.059)	(0.062)	(0.077)	(0.042)	(0.041)	(0.030)	(0.070)	(0.007)	(0.024)
EPSGR	0.137**	0.146**	0.144**	−0.005	−0.011	0.001	0.009	0.006**	−0.002
	(0.049)	(0.049)	(0.050)	(0.008)	(0.012)	(0.006)	(0.038)	(0.003)	(0.006)
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	189,187	189,115	189,283	156,506	156,410	156,578	189,283	189,283	189,283
R-squared	0.899	0.849	0.905	0.150	0.136	0.320	0.786	0.650	0.935

➢ 实证结果

2.横截面回报的证据

对于所有三类排放，依次将公司的碳排放水平、碳排放变化和碳强度回归在相应的横截面股票回报上，使用混合**OLS**估计以下横截面回归模型：

$$RET_{i,t} = a_0 + a_1 LOG\ (TOT\ Emissions)_{i,t} + a_2 Controls_{i,t-1} + \mu_t + \varepsilon_{i,t}, \quad (1)$$

其中，$RET_{i,t}$ 代表股票回报（收益），**Emissions**代表**SCOPE1**、**SCOPE2**和**SCOPE3**排放，**Controls**包括许多已知可预测回报的公司特定变量，**t**表示年/月固定效应。在公司和年份层面对标准误差进行聚类。这里主要关注系数α_1。回归结果如表**8**所示。

由于碳排放倾向于在特定行业内显著聚集，一个值得关注的问题是，企业的具体差异是否可以归因于特定行业的影响。为了检验这种可能性，我们使用**Trucost**行业分类加入了行业固定效应。

Table 8

Carbon emissions and stock returns.

The sample period is 2005–2017. The dependent variable is *RET*. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the firm and year level (in parentheses). All regressions include year-month fixed effects. In the regressions for columns 4 through 6, we additionally include industry-fixed effects. Panel A reports the results for the natural logarithm of total firm-level emissions; Panel B reports the results for the percentage change in carbon total emissions; Panel C reports the results for carbon emission intensity. ***1% significance; **5% significance; *10% significance.

Panel A: Total emissions						
Variables	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	0.043**			0.164***		
	(0.023)			(0.036)		
LOG (SCOPE 2 TOT)		0.098**			0.167***	
		(0.042)			(0.048)	
LOG (SCOPE 3 TOT)			0.135**			0.312***
			(0.046)			(0.071)
LOGSIZE	−0.140	−0.184	−0.193	−0.302*	−0.327*	−0.410**
	(0.163)	(0.167)	(0.165)	(0.148)	(0.154)	(0.163)
B/M	0.460	0.469	0.444	0.656**	0.642**	0.562**
	(0.260)	(0.266)	(0.258)	(0.234)	(0.229)	(0.224)
LEVERAGE	−0.559*	−0.579*	−0.498*	−0.699***	−0.712***	−0.790***
	(0.272)	(0.280)	(0.274)	(0.177)	(0.171)	(0.167)
MOM	0.321	0.348	0.338	0.284	0.294	0.301
	(0.276)	(0.272)	(0.274)	(0.291)	(0.290)	(0.290)
INVEST/A	−2.218	−1.914	−1.587	0.277	0.267	0.699
	(1.740)	(1.794)	(1.838)	(2.111)	(2.126)	(2.082)
ROE	0.010*	0.009	0.008	0.009*	0.009*	0.007*
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
HHI	0.032	−0.026	0.137	0.130*	0.052	0.111
	(0.110)	(0.112)	(0.101)	(0.072)	(0.073)	(0.071)
LOGPPE	−0.015	−0.027	−0.045	0.020	0.019	−0.017
	(0.100)	(0.088)	(0.090)	(0.058)	(0.058)	(0.057)
BETA	0.059	0.023	0.047	0.045	0.040	0.063
	(0.131)	(0.131)	(0.130)	(0.148)	(0.147)	(0.146)
VOLAT	0.978	0.674	0.749	0.622	0.501	0.549
	(3.571)	(3.415)	(3.506)	(3.290)	(3.285)	(3.269)
SALESGR	0.692	0.688	0.672	0.679	0.686	0.648
	(0.429)	(0.430)	(0.420)	(0.412)	(0.412)	(0.407)
EPSGR	0.592**	0.589**	0.575**	0.637**	0.636**	0.615**
	(0.234)	(0.231)	(0.232)	(0.231)	(0.233)	(0.227)
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	184,288	184,216	184,384	184,288	184,216	184,384
R-squared	0.203	0.204	0.204	0.206	0.206	0.206

Panel B: Growth rate in total emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
ΔSCOPE 1	0.641***			0.627***		
	(0.153)			(0.144)		
ΔSCOPE 2		0.345**			0.321**	
		(0.125)			(0.120)	
ΔSCOPE 3			1.203***			1.186***
			(0.318)			(0.314)
LOGSIZE	−0.023	−0.013	−0.037	−0.107	−0.099	−0.121
	(0.110)	(0.112)	(0.111)	(0.114)	(0.115)	(0.117)
B/M	0.391	0.388	0.410*	0.771**	0.764**	0.789***
	(0.232)	(0.233)	(0.226)	(0.257)	(0.257)	(0.246)
LEVERAGE	−0.433*	−0.414*	−0.441*	−0.794***	−0.785***	−0.799***
	(0.217)	(0.216)	(0.213)	(0.213)	(0.217)	(0.214)
MOM	0.204	0.217	0.166	0.160	0.175	0.124
	(0.265)	(0.268)	(0.267)	(0.264)	(0.266)	(0.264)
INVEST/A	−2.508	−2.244	−2.638	−0.620	−0.463	−0.807
	(1.820)	(1.848)	(1.867)	(2.326)	(2.291)	(2.341)
ROE	0.009**	0.009**	0.009**	0.008**	0.008**	0.009**
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
HHI	−0.143	−0.112	−0.162	−0.072	−0.056	−0.089
	(0.154)	(0.153)	(0.151)	(0.098)	(0.097)	(0.102)
LOGPPE	−0.006	−0.015	0.006	0.053	0.045	0.066
	(0.058)	(0.057)	(0.060)	(0.041)	(0.041)	(0.044)
BETA	0.109	0.119	0.106	0.155	0.166	0.145

(Continued on next page)

Table 8
(*Continued*)

Panel B: Growth rate in total emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	(0.165)	(0.165)	(0.168)	(0.158)	(0.157)	(0.162)
VOLAT	1.853	2.004	1.800	1.373	1.504	1.341
	(4.240)	(4.226)	(4.274)	(4.072)	(4.075)	(4.107)
SALESGR	0.459	0.544	0.280	0.463	0.549	0.284
	(0.447)	(0.454)	(0.430)	(0.429)	(0.434)	(0.402)
EPSGR	0.573**	0.573**	0.568**	0.641**	0.641**	0.636**
	(0.247)	(0.246)	(0.250)	(0.263)	(0.263)	(0.266)
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	153,051	152,955	153,123	153,051	152,955	153,123
R-squared	0.218	0.218	0.218	0.221	0.221	0.222

Panel C: Emission intensity						
Variables	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	−0.010			0.005		
	(0.012)			(0.006)		
SCOPE 2 INT		0.145			0.081	
		(0.121)			(0.074)	
SCOPE 3 INT			0.055			0.048
			(0.033)			(0.075)
LOGSIZE	−0.154	−0.133	−0.124	−0.229	−0.230	−0.229
	(0.169)	(0.159)	(0.164)	(0.142)	(0.141)	(0.142)
B/M	0.456	0.470	0.479*	0.732**	0.732**	0.732**
	(0.264)	(0.269)	(0.258)	(0.244)	(0.243)	(0.244)
LEVERAGE	−0.545*	−0.558*	−0.532*	−0.608***	−0.606***	−0.603***
	(0.264)	(0.269)	(0.263)	(0.195)	(0.195)	(0.196)
MOM	0.332	0.321	0.317	0.282	0.282	0.281
	(0.277)	(0.279)	(0.279)	(0.292)	(0.292)	(0.291)
INVEST/A	−1.953	−2.047	−1.916	−0.041	−0.037	−0.022
	(1.815)	(1.823)	(1.867)	(2.123)	(2.127)	(2.134)
ROE	0.010*	0.010*	0.010*	0.010**	0.010**	0.010**
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
HHI	−0.139	−0.069	0.028	−0.032	−0.043	−0.030
	(0.137)	(0.113)	(0.082)	(0.074)	(0.072)	(0.067)
LOGPPE	0.034	0.010	0.006	0.081	0.079	0.080
	(0.099)	(0.087)	(0.093)	(0.065)	(0.064)	(0.066)
BETA	0.047	0.045	0.051	0.035	0.034	0.036
	(0.131)	(0.131)	(0.131)	(0.148)	(0.148)	(0.148)
VOLAT	1.027	0.978	1.028	0.577	0.558	0.572
	(3.512)	(3.527)	(3.563)	(3.296)	(3.297)	(3.300)
SALESGR	0.709	0.714	0.712	0.718	0.719	0.717
	(0.435)	(0.432)	(0.427)	(0.414)	(0.413)	(0.413)
EPSGR	0.600**	0.600**	0.600**	0.660**	0.660**	0.661**
	(0.234)	(0.232)	(0.232)	(0.235)	(0.236)	(0.235)
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	184,384	184,384	184,384	184,384	184,384	184,384
R-squared	0.203	0.203	0.203	0.206	0.206	0.206

Table 9

Carbon emissions and stock returns net of earnings returns.

The sample period is 2005–2017. The dependent variable is *RET* net of daily return realized on the earnings announcement day. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the firm and year level (in parentheses). All regressions include year-month fixed effects. In the regressions for columns 4 through 6, we additionally include industry-fixed effects. Panel A reports the results for the natural logarithm of total emissions; Panel B reports the results for the percentage change in carbon total emissions; Panel C reports the results for carbon emission intensity. ***1% significance; **5% significance; *10% significance.

Panel A: Total emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	0.044*			0.152***		
	(0.024)			(0.031)		
LOG (SCOPE 2 TOT)		0.088**			0.150***	
		(0.040)			(0.044)	
LOG (SCOPE 3 TOT)			0.121**			0.279***
			(0.047)			(0.067)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	184,288	184,216	184,384	184,288	184,216	184,384
R-squared	0.220	0.221	0.220	0.223	0.223	0.223

Panel B: Growth rate in total emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
ΔSCOPE 1	0.552***			0.532***		
	(0.137)			(0.131)		
ΔSCOPE 2		0.288**			0.266**	
		(0.111)			(0.108)	
ΔSCOPE 3			0.896**			0.882**
			(0.313)			(0.316)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	153,051	152,955	153,123	153,051	152,955	153,123
R-squared	0.235	0.236	0.235	0.239	0.239	0.239

Panel C: Emission intensity

Variables	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	−0.008			0.004		
	(0.011)			(0.007)		
SCOPE 2 INT		0.155			0.079	
		(0.124)			(0.068)	
SCOPE 3 INT			0.050			0.029
			(0.032)			(0.071)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	184,384	184,384	184,384	184,384	184,384	184,384
R-squared	0.220	0.220	0.220	0.223	0.223	0.223

➢ 实证结果

表8的面板A显示，所有三类排放对公司股票回报均有正向显著影响。为了检验公司的差异是否归因于特定行业的影响，根据Trucost行业分类增加了行业固定效应。结果如第4到6列所示，加入行业固定效应显著加强了碳排放导致的回报横截面分散程度，且系数大小增加了70%到280%。

表8的面板B显示，排放量增长对回报具有正向显著影响，但是加入行业固定效应前后差别不大。ROE对本回归模型中股票回报有显著的正向影响，这可能是由于排放增长高的公司有更高的收益，进而导致更高的股票回报。

表8面板C显示，无论是否控制行业固定效应，排放强度对三类排放中任何一类的股票回报都没有显著影响。

➢ 实证结果

3.碳溢价和风险因子

碳溢价是否可以被传统风险因子解释？为了回答这个问题，本文使用月度数据估计以下时间序列回归模型：

$$a_{1,t} = c_0 + \boldsymbol{cF_t} + \varepsilon_t, \qquad (2)$$

其中 $a_{1,t}$ 是从方程**(1)**中的横截面**Fama-MacBeth**回归估计的碳溢价。**F**是一组因子模拟投资组合，包括市场因子**(MKTRF)**、价值因子**(HML)**、市值因子**(SMB)**、动量因子**(MOM)**、投资因子**(CMA)**、贝塔因子**(BAB)**、流动性因子**(LIQ)**、净发行因子**(NETISSUANCE)**和异质波动性因子**(IDIOVOL)**。前五个因子对应于**Fama-French**的经典框架。回归结果如表**10**所示。我们感兴趣的系数是 C_0 ，衡量了控制其他风险因子后的剩余碳溢价。

Table 10

Can the carbon premium be explained by risk factors?

The sample period is 2005–2017. The dependent variable is the monthly carbon premium estimated each period using a cross-sectional return regression. All variables are defined in Table 1. We report the results of the time-series regression with standard errors adjusted for autocorrelation with 12 lags using Newey-West test (in parentheses). Panel A reports the results for the natural logarithm of contemporaneous total emissions; Panel B reports the results for the percentage change in carbon emissions; Panel C reports the results for carbon emission intensity. ***1% significance; **5% significance; *10% significance.

Panel A: Total emissions

	LOG (SCOPE 1 TOT)		LOG (SCOPE 2 TOT)		LOG (SCOPE 3 TOT)	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
MKTRF		−1.176		3.298***		3.429**
		(0.714)		(1.084)		(1.357)
HML		−6.020***		−4.284**		−6.444**
		(1.598)		(1.759)		(2.537)
SMB		−0.331		1.184		1.539
		(0.887)		(2.858)		(1.840)
MOM		0.399		−3.853**		−3.580***
		(0.559)		(1.721)		(1.281)
CMA		0.086***		0.053		0.116***
		(0.028)		(0.036)		(0.036)
BAB		0.772		0.303		1.581
		(0.824)		(1.749)		(1.681)
LIQ		2.658***		0.816		3.094***
		(0.768)		(1.135)		(1.016)
NET ISSUANCE		1.250		−1.603		0.376
		(1.015)		(2.207)		(2.352)
IDIO VOL		1.566**		0.986		0.414
		(0.723)		(1.332)		(1.319)
Constant	0.058**	0.053**	0.085**	0.070***	0.103***	0.065**
	(0.026)	(0.023)	(0.037)	(0.027)	(0.035)	(0.027)
Industry adj.	No	No	No	No	No	No
Adj. R2	0.001	0.331	0.001	0.335	0.001	0.247
Observations	156	156	156	156	156	156

Panel B: Growth rate in total emissions

	ΔSCOPE 1		ΔSCOPE 2		ΔSCOPE 3	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
MKTRF		4.847		−2.463		8.303
		(5.605)		(2.516)		(8.965)
HML		−8.427**		−5.897*		−17.483**
		(3.853)		(3.362)		(7.113)
SMB		−15.284**		−9.960*		−23.109*
		(6.419)		(5.667)		(13.738)
MOM		3.223		3.703		9.171
		(4.704)		(2.727)		(8.912)
CMA		−0.159*		−0.153***		−0.468***
		(0.087)		(0.058)		(0.168)
BAB		−8.919***		2.396		11.861
		(3.255)		(2.036)		(8.199)
LIQ		0.808		−1.343		9.512*
		(2.495)		(2.342)		(4.847)
NET ISSUANCE		4.702		1.724		15.976
		(5.262)		(4.821)		(13.211)
IDIO VOL		3.851		6.477*		16.111
		(6.820)		(3.474)		(11.811)
Constant	0.640***	0.643***	0.435***	0.463***	1.559***	1.424***
	(0.089)	(0.120)	(0.065)	(0.063)	(0.237)	(0.250)
Industry adj.	No	No	No	No	No	No
Adj. R2	0.001	0.107	0.001	0.178	0.001	0.290

Table 10
(*continued*)

Panel C: Emission intensity

	SCOPE 1 INT		SCOPE 2 INT		SCOPE 3 INT	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
MKTRF		−0.793***		1.790		0.820
		(0.177)		(2.810)		(0.880)
HML		−0.927***		−6.181		−4.063**
		(0.315)		(4.340)		(1.635)
SMB		−1.027**		−9.486		−0.722
		(0.519)		(6.371)		(1.214)
MOM		0.855***		−1.195		−0.449
		(0.214)		(2.970)		(0.597)
CMA		0.001		0.008		0.039
		(0.007)		(0.101)		(0.031)
BAB		0.302		−4.055		−0.645
		(0.391)		(3.961)		(0.915)
LIQ		0.229		0.372		2.608***
		(0.297)		(2.942)		(0.800)
NET ISSUANCE		0.445		−6.006		−0.139
		(0.304)		(5.742)		(1.159)
IDIO VOL		0.333		8.908***		0.424
		(0.293)		(3.069)		(0.723)
Constant	−0.006	−0.004	0.121	0.181*	0.018	0.012
	(0.008)	(0.007)	(0.102)	(0.097)	(0.027)	(0.028)
Industry adj.	No	No	No	No	No	No
Adj. R2	0.001	0.413	0.001	0.135	0.001	0.104
Observations	156	156	156	156	156	156

➢ 实证结果

3.碳溢价和风险因子

表10的面板A显示：通过比较各自排放范围类别的奇数列和偶数列，我们发现，在对差异因素暴露进行调整后，碳溢价在统计和经济上仍然显著。总的来说，在存在各种风险因素的情况下，横截面收益回归的回归截距在经济和统计上都是显著的。

表10的面板B显示：我们再次发现，一组标准风险因素不能解释任何排放类别的碳溢价的平均值。

表10的面板C显示：无论在风险因素上是无条件的还是有条件的，我们都没有发现显著的碳溢价。

总体而言，我们的时间序列回归结果表明，碳溢价不能被已知的风险因素所解释。这一结果强化了第3.2节的发现，即碳排放水平包含关于横截面平均回报的独立信息。

➢ 实证结果

4.撤资假设

碳溢价的一个可能且重要的解释是机构投资者对高碳排放股票进行撤资导致的分散化不足。由于某些投资者可能会避开高碳排放公司，风险分担将是有限的，异质性风险将会被定价。如果撤资程度较高，预期会看到显著的定价影响。

本文通过机构投资者的持股比例来检验这一假设。正式地，对以下混合回归模型进行估计：

$$IO_{i,t} = d_0 + d_1 Emission_{j,t} + d_2 Controls_{j,t} + \varepsilon_{i,t}. \qquad (3)$$

感兴趣的系数是d_1，该指标衡量的是对碳排放较高企业的回避程度。

不同机构投资者可能面临不同程度的投资者压力，比如保险公司、独立顾问和养老基金可能面临更大的投资者压力，因此他们更可能避开高排放公司。回归结果如表11所示。

Table 11: Carbon Emissions and Institutional Ownership

The sample period is 2005-2017. The dependent variable in Panel A is *IO*. The dependent variables in Panel B, Panel C, and Panel D are *IO_BANK, IO_INSURANCE, IO_INVESTCOS, IO_ADVISERS, IO_PENSIONS,* and *IO_HFS*. Panels A-D present the result for contemporaneous measures of emission intensity. Panel B presents the results for *SCOPE 1*, Panel C presents the results for *SCOPE 2*, and Panel D presents the results for *SCOPE 3*. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the industry and year level. All regressions include year-month fixed effects. In Panel A, columns (2), (4), and (6) additionally include state-fixed effects. All regressions in Panels B-D include state fixed effects. ***1% significance; **5% significance; *10% significance.

Panel A: Aggregate ownership (Emission intensity)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	-0.194**	-0.218**				
	(0.085)	(0.083)				
SCOPE 2 INT			-0.383	-0.381		
			(1.621)	(1.610)		
SCOPE 3 INT					0.094	-0.130
					(0.550)	(0.581)
LOGSIZE	2.078	1.847	2.096	1.859	2.104	1.850
	(1.510)	(1.702)	(1.484)	(1.678)	(1.499)	(1.706)
PRINV	-29.353***	-37.098***	-29.333***	-37.161***	-29.308***	-37.200***
	(5.614)	(6.448)	(5.611)	(6.392)	(5.640)	(6.476)
MOM	-1.453	-1.792*	-1.542	-1.871**	-1.544	-1.858*
	(0.937)	(0.876)	(0.895)	(0.823)	(0.920)	(0.856)
B/M	-1.165	-0.890	-1.533	-1.205	-1.498	-1.216
	(1.423)	(1.602)	(1.366)	(1.541)	(1.339)	(1.549)
BETA	9.123***	9.470***	9.332***	9.705***	9.300***	9.695***
	(1.508)	(1.459)	(1.421)	(1.375)	(1.430)	(1.388)
VOLAT	-7.617	4.118	-6.867	4.770	-7.095	4.532
	(14.257)	(12.827)	(13.550)	(11.939)	(14.024)	(12.565)
VOLUME	-4.427***	-4.612**	-4.379***	-4.568**	-4.389***	-4.582**
	(1.400)	(1.636)	(1.422)	(1.650)	(1.378)	(1.626)
NASDAQ	-1.159	-1.529	-0.875	-1.255	-0.751	-1.292
	(1.467)	(1.700)	(1.431)	(1.638)	(1.303)	(1.505)
SP500	2.559	1.711	2.418	1.508	2.394	1.510
	(2.120)	(2.093)	(2.122)	(2.088)	(2.129)	(2.095)
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effect	No	Yes	No	Yes	No	Yes
Observations	170,701	160,406	170,701	160,406	170,701	160,406
R-squared	0.121	0.166	0.118	0.162	0.118	0.162

Panel B: Disaggregate ownership

Variables	(1) Banks	(2) Insurance	(3) Invest. Cos.	(4) Advisers	(5) Pensions	(6) Hedge Funds
SCOPE 1 INT	0.001**	−0.011*	0.026	−0.258***	−0.009*	0.033
	(0.000)	(0.005)	(0.022)	(0.056)	(0.004)	(0.028)
SCOPE 2 INT	0.009	−0.253	−0.139	−0.156	0.049	0.108
	(0.006)	(0.144)	(0.406)	(0.992)	(0.097)	(0.441)
SCOPE 3 INT	0.004*	−0.021	0.038	0.052	0.028	−0.230
	(0.002)	(0.071)	(0.115)	(0.409)	(0.030)	(0.151)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	160,406	160,406	160,406	160,406	160,406	160,406

➢ 实证结果

4.撤资假设

总体而言，机构投资者确实从与高SCOPE1 INT（排放强度）相关的公司中大幅撤资。他们不会根据公司的排放水平(或排放增长)来筛选公司，即使碳溢价与这些变量相关，他们更喜欢根据公司使用化石燃料能源的效率来筛选公司，而似乎并不关心减少他们对碳排放水平的风险敞口。

我们从这些发现中得出的结论是，与“罪恶”股票不同(如Hong和kacperzyk, 2009)，撤资导致的有限风险分担不能单独解释对于为什么对于高排放水平（增长率）的公司我们会观察到碳溢价。

➢ 实证结果

5.粗略分类

人们普遍认为只有少数几个行业产生了最重要的碳排放部分。因此，本文希望探索如果将典型行业(石油和天然气、公用事业和运输行业)排除在分析之外，横截面碳溢价是否会显著降低。回归结果如表**12**所示。

由表**12**可以看出，排除典型行业会加强公司层面碳溢价的结果，这意味着典型行业内的投资者对公司进行了更粗略的分类，这些行业的股票回报对不同公司的碳排放差异不太敏感。

根据排除典型行业后机构持股的结果（表**13**），正是粗略的行业级别分类推动了撤资结果。事实上，其他行业没有明显撤资。总体而言，对于不同类别的投资者来说都是如此。从这一结果，本文推断投资者通过从某些公司撤资来减少对某些行业的敞口，但仍然保留了这些行业中**scope1**碳排放强度最低的公司。

Table 12

Carbon emissions and stock returns: excluding salient industries.

The sample period is 2005–2017. The dependent variable is *RET*. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the industry level (in parentheses). The sample excludes companies in the oil and gas (gic=2), utilities (gic=65–69), and transportation (gic=18, 19, 23) industries All regressions include year-month fixed effects. In the regressions for columns 4–6, we additionally include industry-fixed effects. Panel A reports the results for the natural logarithm of total emissions; Panel B reports the results for the percentage change in carbon emissions; Panel C reports the results for carbon emission intensity. ***1% significance; **5% significance; *10% significance.

Panel A: Total emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	0.072**			0.177***		
	(0.025)			(0.044)		
LOG (SCOPE 2 TOT)		0.097**			0.227***	
		(0.039)			(0.057)	
LOG (SCOPE 3 TOT)			0.117**			0.324***
			(0.048)			(0.074)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	164,094	164,166	164,190	164,094	164,166	164,190
R-squared	0.213	0.213	0.213	0.216	0.216	0.216

Panel B: Growth rate in total emissions

Variables	(1)	(2)	(3)	(4)	(5)	(6)
ΔSCOPE 1	0.657***			0.630***		
	(0.151)			(0.142)		
ΔSCOPE 2		0.463***			0.438***	
		(0.117)			(0.112)	
ΔSCOPE 3			1.480***			1.456***
			(0.321)			(0.322)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	135,522	135,570	135,594	135,522	135,570	135,594
R-squared	0.230	0.230	0.230	0.233	0.233	0.233

Panel C: Emission intensity

Variables	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	0.004			−0.012		
	(0.016)			(0.016)		
SCOPE 2 INT		0.154			0.150	
		(0.102)			(0.112)	
SCOPE 3 INT			0.054			0.160*
			(0.035)			(0.078)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	164,190	164,190	164,190	164,190	164,190	164,190
R-squared	0.213	0.213	0.213	0.216	0.216	0.216

Table 13

Carbon emissions and institutional ownership: excluding salient industries.

The sample excludes companies in the oil & gas (gic=2), utilities (gic=65–69), and transportation (gic=18, 19, 23) industries. The sample period is 2005–2017. Panel A presents the results for aggregate ownership for contemporaneous carbon intensity measures, Panel B for disaggregated ownership. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the industry and year level (in parentheses). All regressions include year-month fixed effects. In Panel A, the regressions for columns 2, 4, and 6, the regressions additionally include state-fixed effects. All regressions for Panel B results include state fixed effects. ***1%; **5%; *10% significance.

Panel A: Aggregate ownership

Variables	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	−0.015	−0.007				
	(0.094)	(0.104)				
SCOPE 2 INT			−0.565	−0.525		
			(1.968)	(2.024)		
SCOPE 3 INT					0.421	0.246
					(0.538)	(0.568)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effect	No	Yes	No	Yes	No	Yes
Observations	152,799	143,337	152,799	143,337	152,799	143,337
R-squared	0.126	0.169	0.126	0.169	0.127	0.170

Panel B: Disaggregate ownership

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Banks	Insurance	Invest. Cos.	Advisers	Pensions	Hedge Funds
SCOPE 1 INT	0.001*	−0.013	−0.059	−0.060	0.009	0.114
	(0.000)	(0.012)	(0.041)	(0.078)	(0.010)	(0.068)
SCOPE 2 INT	0.006	−0.298*	−0.320	−0.224	0.051	0.261
	(0.006)	(0.164)	(0.487)	(1.252)	(0.124)	(0.523)
SCOPE 3 INT	0.004*	−0.015	0.063	0.436	0.041	−0.282
	(0.002)	(0.077)	(0.125)	(0.376)	(0.031)	(0.170)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	143,337	143,337	143,337	143,337	143,337	143,337

➢ 实证结果

6.投资者意识

股票回报中的碳溢价也可能受到投资者对碳风险意识变化的影响。利用双重差分模型**DID**：

$$RET_{i,t} = e_0 + e_1 TREAT * AFTER_{j,t} + e_2 Controls_{i,t} + e_3 \mu_i + e_4 \mu_t + \varepsilon_{i,t}, \quad (4)$$

我们感兴趣的系数是 e_1，它衡量了投资者意识变化对高排放企业和低排放企业的不同影响。

结论：**1990s**之前，投资者还没有将碳风险内在化，但在过去**20**年里，随着气候变化、全球变暖影响、可再生能源技术进步以及遏制碳排放的政治行动的加强，投资者开始将碳风险内在化。（表**16**所示）

Table 14
Carbon emissions and stock returns: sub-periods.

The sample period is 2005–2017. The dependent variable is *RET*. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the firm and year/month level (in parentheses). All regressions include year-month fixed effects and industry-fixed effects. We report the results for the natural logarithm of contemporaneous total emissions in Panel A; the results for the growth rate in firm emissions in Panel B; and the results for emission intensity in Panel C. ***1% significance; **5% significance; *10% significance.

Panel A: Total emissions

	2005–2015			2016–2017		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	0.127***			0.205**		
	(0.037)			(0.075)		
LOG (SCOPE 2 TOT)		0.127***			0.233**	
		(0.042)			(0.087)	
LOG (SCOPE 3 TOT)			0.265***			0.340***
			(0.086)			(0.107)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	121,694	121,622	121,778	62,594	62,594	62,606
R-squared	0.268	0.269	0.269	0.115	0.115	0.115

Panel B: Growth rate in total emissions

	2005–2015			2016–2017		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
ΔSCOPE 1	0.610***			0.629**		
	(0.161)			(0.249)		
ΔSCOPE 2		0.265***			0.459**	
		(0.097)			(0.193)	
ΔSCOPE 3			1.259***			1.032**
			(0.355)			(0.436)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	108,888	108,804	108,948	44,163	44,151	44,175
R-squared	0.278	0.279	0.279	0.089	0.089	0.089

Panel C: Emission intensity

	2005–2015			2016–2017		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	0.005			0.010		
	(0.007)			(0.019)		
SCOPE 2 INT		0.091			0.117	
		(0.094)			(0.125)	
SCOPE 3 INT			0.030			0.040
			(0.091)			(0.087)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	121,778	121,778	121,778	62,606	62,606	62,606
R-squared	0.268	0.268	0.268	0.114	0.114	0.114

Table 16
Carbon emissions and stock returns (imputed emissions).

The sample period is 1990–1999. The dependent variable is *RET*. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the firm and year level (in parentheses). All regressions include year-month fixed effects. In the regressions for columns 4 through 6, we additionally include industry-fixed effects. The total level of emissions is imputed using the earliest observed level of emission intensity for each firm for the period 2005–2017 (in Panel A) and for 1990–1999 (in Panel B) and scaling it by respective revenue values. ***1% significance; **5% significance; *10% significance.

Panel A: (2005–2017)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	0.097***			0.291***		
	(0.024)			(0.046)		
LOG (SCOPE 2 TOT)		0.186***			0.336***	
		(0.043)			(0.065)	
LOG (SCOPE 3 TOT)			0.245***			0.585***
			(0.043)			(0.127)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	161,122	161,062	161,313	161,122	161,062	161,313
R-squared	0.199	0.200	0.200	0.203	0.203	0.204

Panel B: (1990–1999)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	−0.037			0.082		
	(0.034)			(0.078)		
LOG (SCOPE 2 TOT)		0.033			0.236	
		(0.045)			(0.134)	
LOG (SCOPE 3 TOT)			0.005			0.318*
			(0.059)			(0.162)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	Yes	Yes	Yes
Observations	59,878	59,878	59,878	59,878	59,878	59,878
R-squared	0.149	0.149	0.149	0.156	0.156	0.156

Table A.6: Carbon Emissions and Legacy Stock Returns: Sub-Periods

The sample is restricted to firms that show up in the data prior to 2016. The sample periods are 2005-2015 and 2016-2017. The dependent variable is *RET*. All variables are defined in Table 1. We report the results of the pooled regression with standard errors clustered at the firm and year-month level. All regressions include year-month fixed effects and industry-fixed effects. Panel A reports the results for the natural logarithm of total emissions; Panel B reports the results for the percentage change in carbon emissions; Panel C reports the results for carbon emission intensity. ***1% significance; **5% significance; *10% significance.

Panel A: Total emissions

	2005-2015			2016-2017		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
LOG (SCOPE 1 TOT)	0.151***			0.019		
	(0.039)			(0.057)		
LOG (SCOPE 2 TOT)		0.148***			-0.002	
		(0.042)			(0.044)	
LOG (SCOPE 3 TOT)			0.320***			-0.026
			(0.087)			(0.113)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	122,118	122,046	122,202	25,867	25,867	25,879
R-squared	0.266	0.266	0.266	0.133	0.133	0.133

Panel B: Growth rate in total emissions

	2005-2015			2016-2017		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
ΔSCOPE 1	0.671***			0.273		
	(0.154)			(0.239)		
ΔSCOPE 2		0.319***			0.049	
		(0.111)			(0.197)	
ΔSCOPE 3			1.323***			0.365
			(0.406)			(0.626)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	109,266	109,182	109,326	25,867	25,855	25,879
R-squared	0.276	0.276	0.276	0.133	0.133	0.133

Panel C: Emission intensity

	2005-2015			2016-2017		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
SCOPE 1 INT	0.006			0.017		
	(0.007)			(0.020)		
SCOPE 2 INT		0.076			0.085	
		(0.095)			(0.095)	
SCOPE 3 INT			0.037			-0.076
			(0.091)			(0.101)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year/month F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	122,202	122,202	122,202	25,879	25,879	25,879

➢ 研究结论

1. How is climate change affecting stock returns? This is a fundamental question for the burgeoning field of climate change and finance. It is also a fundamental question for policy makers who are seeking to enlist investors in the fight against climate change. We address this question by undertaking a cross-sectional stock returns analysis, with carbon emissions as a firm characteristic, and find robust evidence that carbon emissions significantly and positively affect stock returns.
2. Whether through the production of their goods and services, or through the use of their products,firms are differentially affected by policies to curb carbon emissions and by renewable-energy technology shocks. Our evidence suggests that investors are discerning these cross-sectional differences and are pricing in carbon risk.

➢ 研究结论

3. We also find that the carbon premium cannot be explained through a sin stock divestment effect. Divestment takes place in a coarse way in a few industries such as oil and gas, utilities, and automobiles, and is entirely based on scope 1 emission intensity screens.

4. Notably, we find no carbon premium associated with emission intensity. Moreover, outside the salient industries where all the divestment takes place, we find a robust, persistent, and significant carbon premium at the firm level for all three categories of emission levels and growth rates.

Thank you