

The Green Innovation Premium: Evidence from U.S. Patents and the Stock Market

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Motivation

The next 1,000 unicorns won't be search engines or social media companies, they'll be sustainable, scalable innovators – startups that help the world decarbonize and make the energy transition affordable for all consumers. — Larry Fink

- ▶ **Green technology plays a crucial role in combating climate change.**

Inflation Reduction Act (IRA): The most significant legislation on climate change and set forth a new era of green innovation.

- ▶ **Do investors care about green innovation commitment?**

- ▶ Brown activities: carbon emissions and industrial pollution.
- ▶ Guide policymakers in designing incentives and regulations to promote clean technology.

- ▶ **Limitation in existing measure: green patent shares.**

- ▶ Not comprehensive enough: the creation of new technologies v.s. successful adoption and deployment on a large scale.
- ▶ Not precise enough: Not all patents are equally used and important; time lag behind current R&D activities.

Outline

Main contribution: Provide a firm-level green innovation measure and study how it is priced in the cross-section of stock markets.

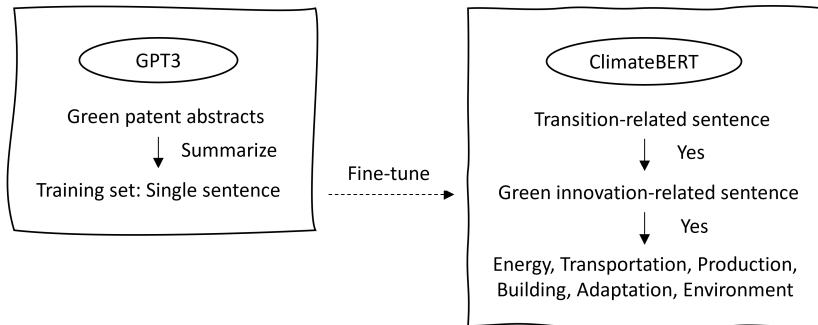
New measures:

- ▶ Utilize ClimateBERT along with GPT-3 models to analyze patent abstracts and earnings call transcripts.
- ▶ Offer a broader view of green innovation activities:
 - ▶ Creating a new technology.
 - ▶ Implementing existing technologies in new contexts or at larger scales or faster speeds. e.g., Renovare Environmental: provides solutions to convert municipal solid waste into renewable fuel on a large scale; partnering with higher education institutions.

Asset pricing implications:

- ▶ Companies with increased green innovation commitments exhibit lower expected returns.
- ▶ Such firms also demonstrate reduced carbon emission levels and fewer negative climate incidents in subsequent years.
- ▶ These firms began to outperform in the last two years, attributed to a sharp increase in attention to green innovation.

NLP method



Firm-level green innovation measure:

The number of sentences pertaining to green innovation scaled by the number of all sentences within each transcript.

$$Greenness_{i,t} = \frac{N_{i,t}^{green}}{N_{i,t}}$$

Excerpts from patent abstracts and earnings calls

Example 1: Echelon Corp. - Patent in Building.

Patent title: Systems, apparatuses, and methods for detecting problems in air.

Abstract: The combination of LED lighting and particulate detectors are enhanced by exploiting the light degradation/reflection/wavelengths detected, absorbed or frequency shift seen in lighting due to the presence of smoke, gas or other molecules (such as explosives) in the air can be detected. The use of LEDs is expanded well beyond simple lighting and energy savings to include not only smoke and fire detection by also to scan for gases and particulates found based in the usage environment.

GPT-3 summarization: This technology uses LED lights to detect problems in the air, like smoke, fire, gases, and particulates, to make buildings safer.

Detected sentences in an earnings call:

(2014-11-06) Smart Controls is focused on monitoring indoor temperature, humidity, CO2, and VoC levels. This is in addition to the numerous safety benefits and the significant energy and cost savings of as much as 90% over their old lighting system.

Excerpts from patent abstracts and earnings calls

Example 2: Workhorse Group Inc. - No green patent in the discussion year.

Detected sentences in an earnings call [Transportation]:

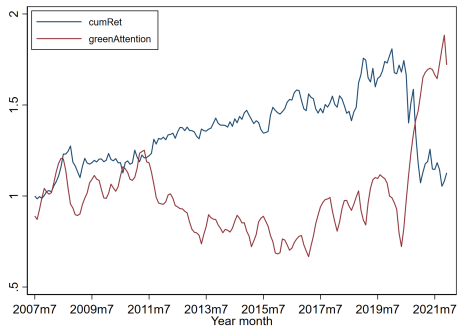
(2016-11-10) And so that's a very sophisticated vehicle, much more sophisticated than a – just an electric vehicle, adding another powertrain in there. All Workhorse vehicles make the movement of people and goods more efficient and less harmful to our environment.

Key differences:

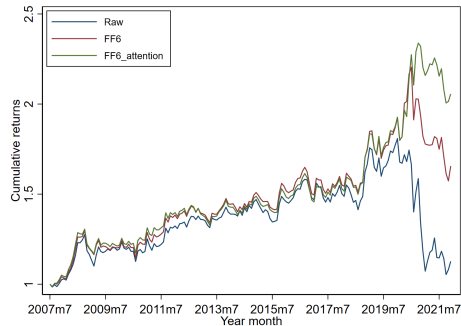
- ▶ Broader information: Firms without green patents can discuss green innovation activities that are unfeasible to patent.
- ▶ More precise assessment: The limited length of earnings calls only allows for discussion of important green innovation commitments in real time.

Green innovation premium:

- ▶ The green innovation negatively predicts future returns.
- ▶ Green firms outperform their less green peers after 2020, which correlates with increased attention to green innovations.
- ▶ The contrasting effect vanishes after accounting for unexpected attention, displaying a consistent negative pattern.



(a)



(b)

Hedging transition risks: Environmental performance

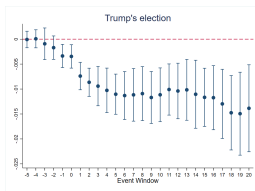
Green innovation $\uparrow \rightarrow$ carbon emissions \downarrow , climate incidents \downarrow .

	(1) Green	(2) Energy	(3) Transp	(4) Prod	(5) Build	(6) Adapt	(7) Envir
Panel A: Carbon emission level scope 1							
Innovation $_{i,t}$	-0.28*** (-2.72)	-0.25** (-2.45)	-0.10 (-1.28)	-0.07* (-1.76)	-0.07** (-2.18)	-0.15** (-2.25)	0.12* (1.69)
Innovation $_{i,t-1}$	-0.27*** (-2.84)	-0.28*** (-2.77)	-0.06 (-1.03)	-0.05 (-1.48)	-0.14*** (-2.83)	-0.13** (-2.10)	0.09 (1.49)
Innovation $_{i,t-2}$	-0.09 (-1.00)	-0.16* (-1.75)	-0.05 (-0.57)	-0.02 (-0.66)	-0.11** (-2.23)	-0.07 (-1.40)	0.10* (1.79)
Innovation $_{i,t-3}$	-0.21* (-1.76)	-0.24** (-2.25)	-0.09 (-1.09)	-0.06 (-1.57)	-0.06 (-1.07)	-0.04 (-0.97)	0.01 (0.15)
Panel B: Number of negative climate incidents							
Innovation $_{i,t}$	0.00 (0.23)	-0.02* (-1.80)	0.01 (0.30)	0.00 (0.09)	-0.00 (-0.08)	0.00 (0.25)	0.02* (1.84)
Innovation $_{i,t-1}$	-0.04*** (-2.60)	-0.01 (-1.07)	-0.02 (-1.20)	-0.04*** (-3.13)	-0.03** (-2.50)	-0.04*** (-3.42)	0.01 (0.98)
Innovation $_{i,t-2}$	-0.02 (-0.80)	-0.01 (-0.40)	-0.03 (-1.48)	-0.00 (-0.09)	-0.02* (-1.80)	-0.02 (-1.38)	0.02 (1.32)
Innovation $_{i,t-3}$	0.01 (0.37)	0.01 (0.41)	-0.02 (-1.09)	0.01 (0.85)	-0.00 (-0.41)	0.00 (0.11)	0.01 (1.01)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

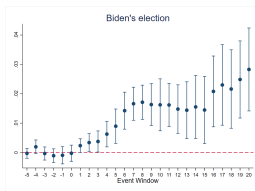
Hedging transition risks: Event study

$$CAR_i = \alpha + \beta \cdot Greenness_i + \gamma X_i + \epsilon_i$$

- Green firms exhibit greater resilience and adaptability facing potentially stringent environmental policies.



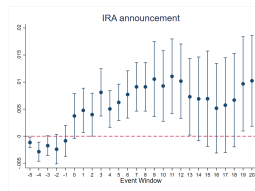
(a)



(b)



(c)



(d)

Comparison with green patents

- In the absence of green discussions, green patents might not significantly affect operational processes.

	(1) CarbonIntensity ^{scope1}	(2) CarbonEmission ^{scope1}	(3) Number	(4) Severity
Panel A: w/ earnings calls & w/o green patents				
Greenness _{<i>i,t</i>}	-0.31** (-2.22)	-0.29** (-2.45)	0.01 (0.35)	0.02 (0.74)
Greenness _{<i>i,t-1</i>}	-0.22 (-1.51)	-0.30*** (-2.67)	-0.04** (-2.15)	-0.05** (-2.22)
Greenness _{<i>i,t-2</i>}	-0.23* (-1.72)	-0.13 (-1.19)	-0.01 (-0.59)	0.00 (0.01)
Greenness _{<i>i,t-3</i>}	-0.38*** (-2.74)	-0.21* (-1.72)	-0.00 (-0.08)	-0.02 (-0.68)
Panel B: w/ patents & w/o green discussions				
Green ^S _{<i>i,t</i>}	0.03 (0.36)	0.41 (0.93)	-0.02 (-0.11)	0.08 (0.48)
Green ^S _{<i>i,t-1</i>}	-0.01 (-0.11)	0.32 (0.88)	-0.02 (-0.15)	0.00 (0.02)
Green ^S _{<i>i,t-2</i>}	-0.04 (-0.64)	0.28 (0.95)	0.09 (1.14)	0.03 (0.32)
Green ^S _{<i>i,t-3</i>}	-0.08* (-1.66)	0.25 (1.02)	0.02 (0.17)	0.14 (1.18)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

Comparison with green patents

- Green innovation activities beyond patents are also priced in the stock markets and are perceived as a hedge against transition risks.

	w/ green discussion & w/o green patents				w/ green patents & w/o green discussions		
	CAR[0,1]	CAR[0,5]	CAR[0,10]		CAR[0,1]	CAR[0,5]	CAR[0,10]
Panel A: Trump's election							
Greenness	-0.004*	-0.007*	-0.011**	Green ^S	0.002	-0.007	-0.006
	(-1.929)	(-1.696)	(-2.168)		(0.641)	(-0.782)	(-0.581)
Observations	378	378	378	Observations	194	194	194
Panel B: Biden's election							
Greenness	0.003	0.009***	0.014***	Green ^S	-0.002	0.001	-0.009
	(1.330)	(3.173)	(3.426)		(-0.584)	(0.166)	(-1.538)
Observations	461	461	461	Observations	198	198	198
Panel C: Russia-Ukraine war							
Greenness	0.004**	0.009***	0.018***	Green ^S	0.008**	0.007	0.003
	(2.219)	(3.411)	(3.593)		(2.362)	(0.488)	(0.217)
Observations	633	633	633	Observations	176	176	176
Panel D: IRA announcement							
Greenness	0.000	-0.001	0.002	Green ^S	0.007	0.000	-0.021
	(0.032)	(-0.206)	(0.458)		(1.430)	(0.051)	(-1.036)
Observations	623	623	623	Observations	172	172	172

Conclusion

- ▶ We construct firm-level green innovation measures from patent abstracts and earnings call transcripts.
- ▶ A portfolio that is long (short) on firms with low (high) greenness generates an average return of about 6% per year.
- ▶ The surge in investors' attention to green innovation recently results in increased demand and prices for green firms.
- ▶ Green technology enables firms to reduce their future carbon emissions and minimize climate incident involvements.

→ Green innovation is essential for both firms and society as a whole to make the transition toward a low-carbon economy.