Navigating Emission Reduction: The Interaction of Disclosure Regulation and Institutional Support in China

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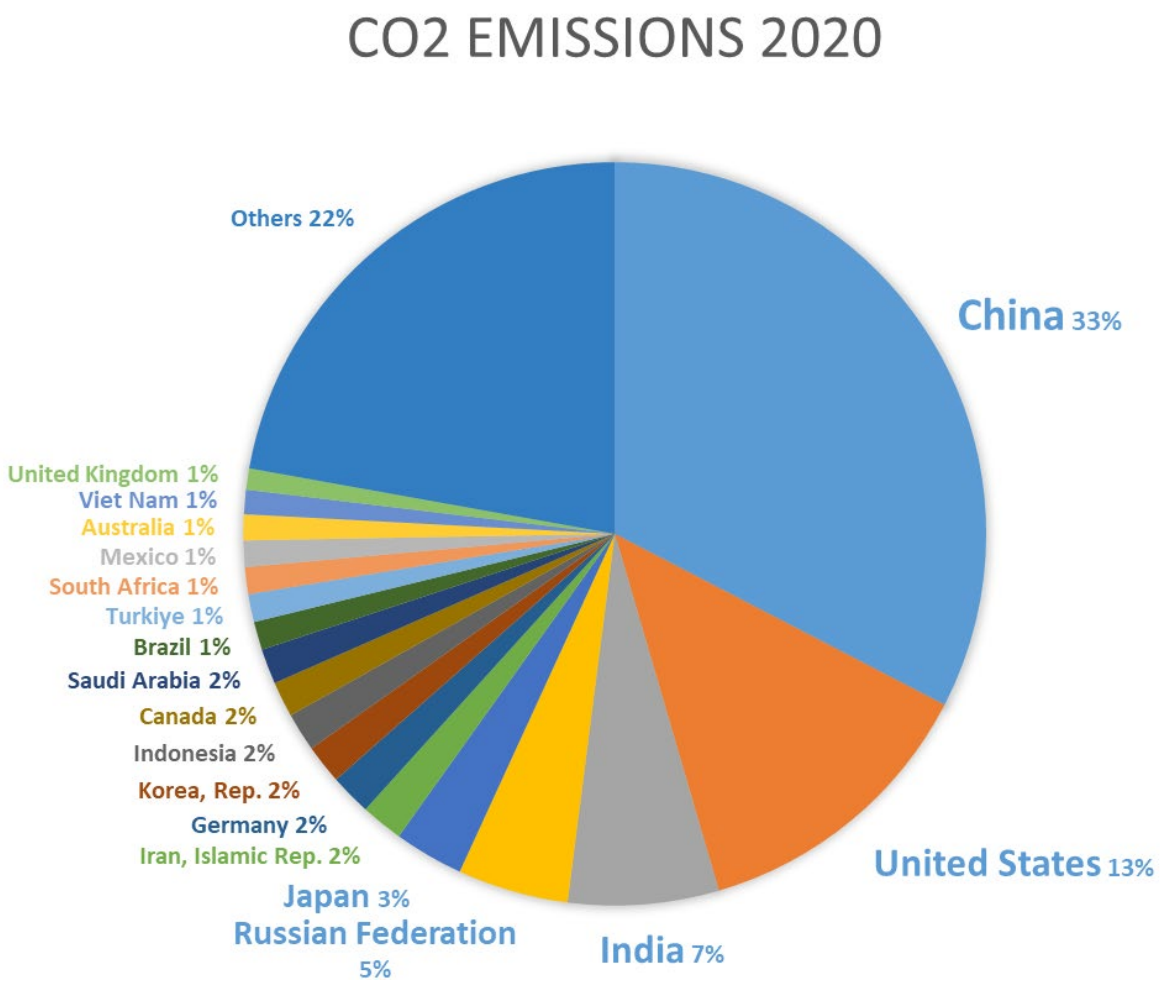
ABFER Accounting Conference
May 23, 2024

Motivations

- China has to play a crucial role in the global efforts to reduce carbon emissions.

- China's "Dual Carbon" goals:
  - Peak carbon emissions by 2030
  - Carbon neutrality by 2060

- How does China reduce its emissions?
- How does disclosure help in this process?
- Is disclosure alone sufficient?



Source: Word Bank

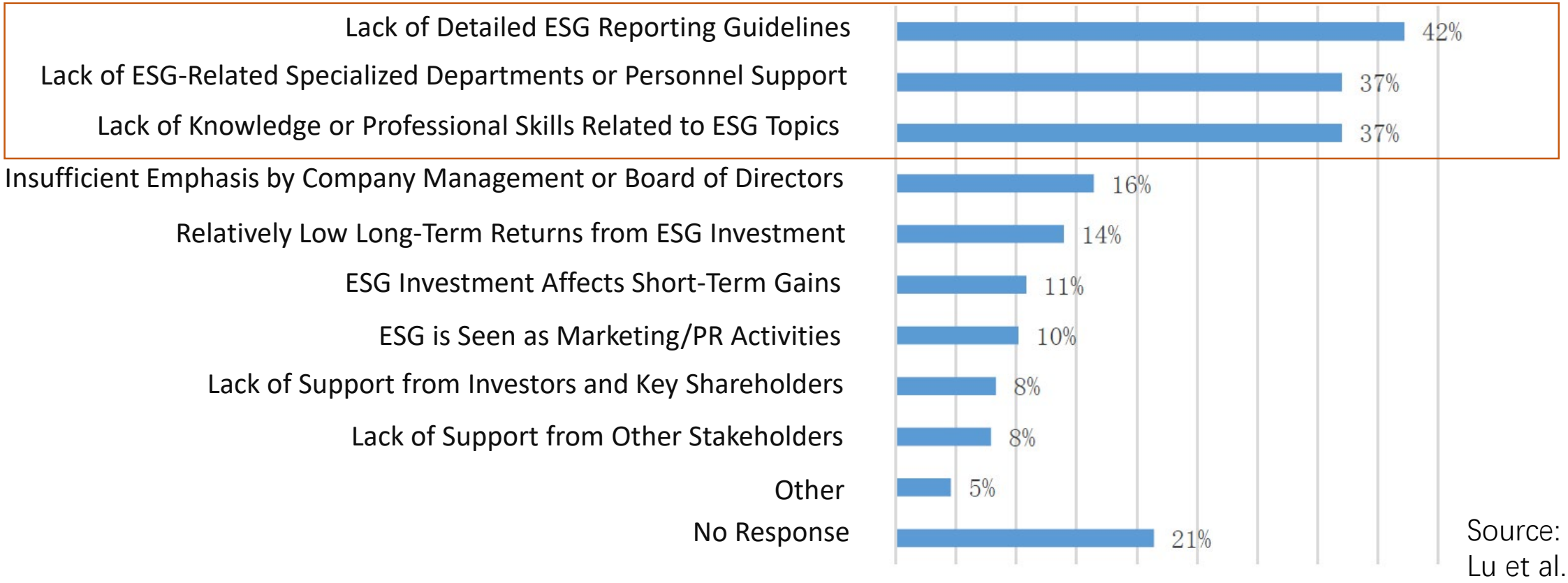
Research Questions

- The June 2021 disclosure regulation to support China's *Dual Carbon* goals:
  - Listed firms are required to include an "Environmental and Social Responsibility" section in their annual reports.
  - Explicitly encouraged to disclose the measures taken to reduce their carbon emissions and the effects within this section.

Research question 1: Does the disclosure regulation effectively reduce carbon emissions in Chinese firms?

Research Questions

The major difficulties for firms to incorporate ESG topics into their strategic planning (N=597):



Source:
Lu et al. (2021)

Research question 2: What are the key conditions necessary for the regulation to achieve its intended purposes?

Main Findings

- On average, firms reduce carbon intensity and emissions following the disclosure regulation.

- The effect of the disclosure regulation is observed solely among firms with human capital and financial support.

Brief Literature Review/Motivations

- Prior studies find that firms reduce carbon emissions following GHG disclosure mandates.
  - Downar et al. (2021) and Jouvenot and Krueger (2021) find that firms reduce carbon emissions and intensity following *a UK mandate requiring them to report their GHG emissions in annual reports.*
  - Tomar (2023) finds that following *a US regulation that requires industrial facilities to measure and report their GHG emissions*, the facilities benchmark their own emissions to their peers and reduce emissions following the mandate.

- These studies
  - Provide evidence from countries with well-established institutional mechanisms for reducing carbon emissions
  - Examine carbon disclosure mandates as standalone regulations

Background of the regulation

The CSRC implemented a disclosure regulation in June 2021:

- A mandatory E&S section in annual report.
- A subsection specifically for disclosing the carbon reduction efforts: “Applicable” or “Not applicable”

- We expect firms to disclose unless their carbon emissions are insignificant.
  - Firms need to appear politically legitimate (Marquis and Qian 2014).
  - The disclosure regulation serves as a strong signal from the government.
  - Political cost associated with non-compliance makes the regulation de facto mandatory.

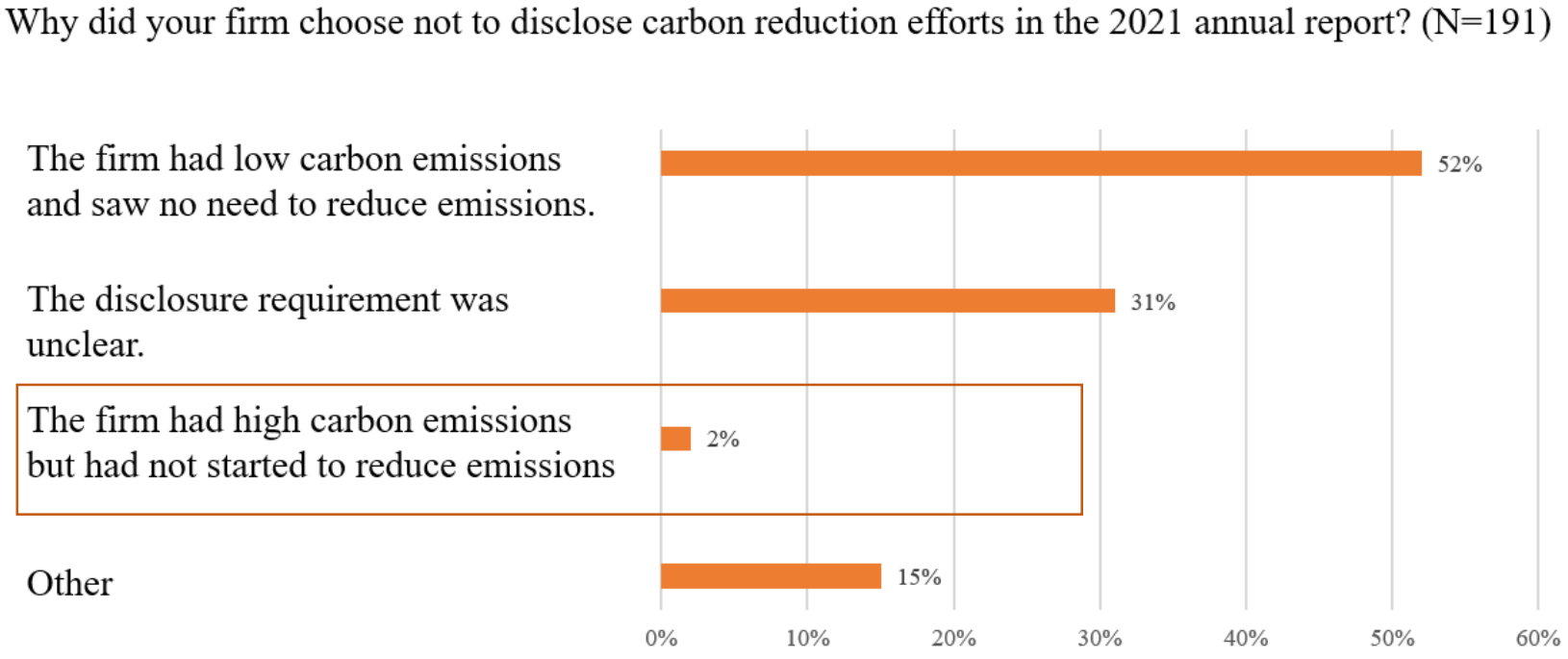
- We expect firms to make truthful disclosures.
  - The government can verify firms’ disclosure through private information channels.

Mandatory Nature of Regulation: Survey Evidence

- 535 valid respondents: 64% disclose, 36% not applicable

At least 83% (=64%+36%*52%) of the survey respondents interpreted the regulation as if it were a mandatory requirement.

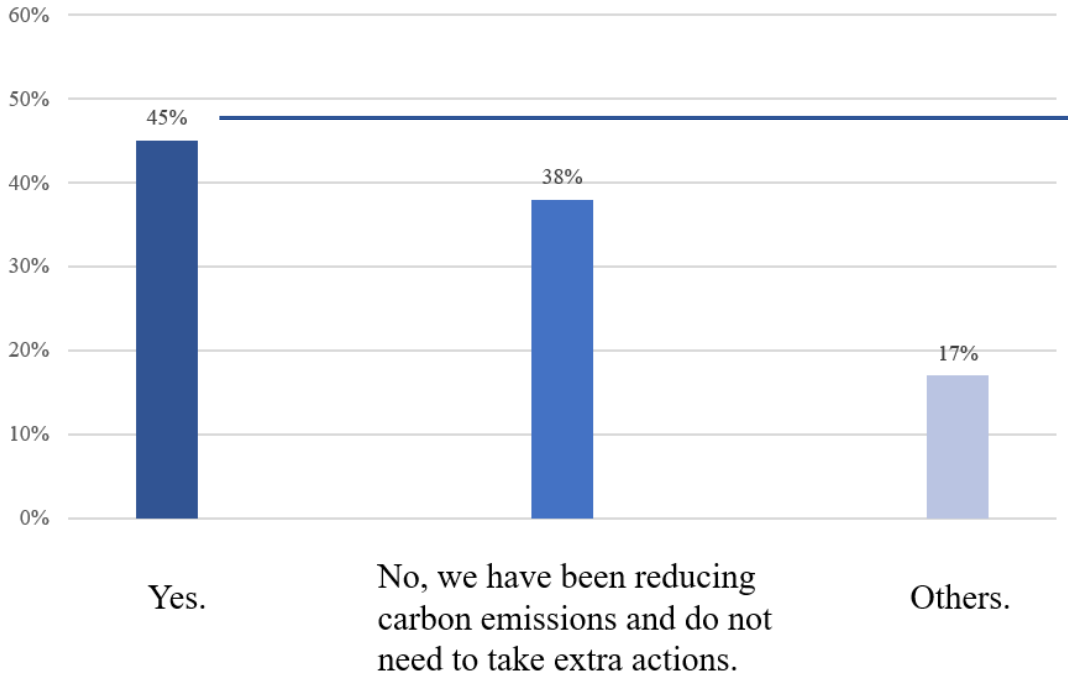
Less than 1% (=36%*2%) avoided disclosure because they had not reduced emissions.



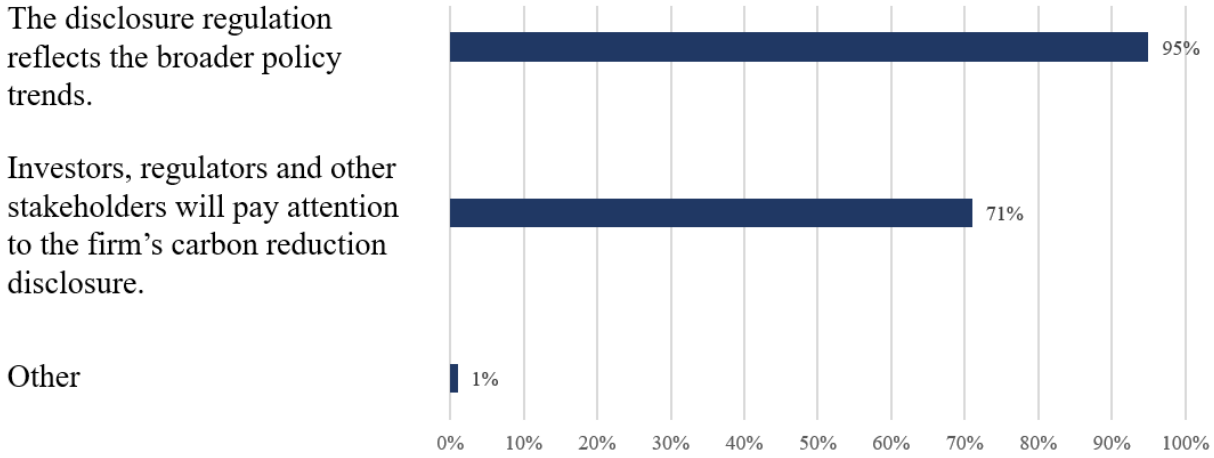
Mandatory Nature of Regulation: Survey Evidence

- **64% disclose**, 36% not applicable

Did your firm increase carbon reduction efforts in response to the disclosure regulation? (N=328)



Why did your firm increase carbon reduction efforts in response to the disclosure regulation? (N=146)



Mandatory Nature of Regulation: Determinant Test

- Disclosing firms are not concentrated in any industries.
- Firms with larger historical carbon emissions are more likely to disclose.
- Past disclosure is not a significant determinant of firms' compliance with the 2021 regulation.

	CSI 800 sample *Treat*
Size	.359**
	(2.442)
ROA	3.306
	(1.464)
PB	-.072**
	(-2.184)
SOE	.1
	(.421)
InstHolding	.029
	(1.287)
Oversea	-.392
	(-.658)
AnalystCov	.044
	(.324)
ESG	.113
	(.792)
CSRReport	.274
	(1.029)
MDA2020	.377
	(1.138)
RepQuality	-.177
	(-.919)
EmissionPCA	.483***
	(3.531)
Industry fixed effects	Yes
Constant	-9.296**
	(-2.555)
Observations	573
Pseudo R^2	.205

Hypothesis Development

- The disclosure regulation increases transparency of firms' carbon management.
- The increased transparency facilitate monitoring by:
  - The government
  - Other stakeholders like ESG rating agencies and customers
- Firms are likely to take actions to reduce carbon emissions (Matsumura et al. 2014; Downar et al. 2021; Amel-Zadeh and Serafeim 2018; Christensen et al. 2021).

  H1a: Firms that disclose their carbon reduction efforts in response to the regulation reduce carbon intensity more than the firms that do not disclose.

- Increased production could counteract the efforts to lower emissions.

  H1b: Firms that disclose their carbon reduction efforts in response to the regulation reduce carbon emissions more than the firms that do not disclose.

Hypothesis Development

- However, emission reduction may not be easily attainable even with increased incentives.
- A global survey in 2021 reveals that while 96% of surveyed companies set emissions reduction targets, only 11% achieved these targets over the past five years (Degot et al. 2021).
- Two major challenges
  - Lack of human capital: Specialized professionals in emissions verification and reduction strategies are scarce in China (Lu, Shin, and Wang, 2023).
  - Financial constraints: Emission reduction initiatives often require significant upfront investments with longer payback periods.

H2: The disclosing firms experience an incremental decrease in carbon intensity (emissions) relative to the non-disclosing firms only when the necessary policy supports are available.

Research Design for H1

$$Carbon_{it} = \beta_0 + \beta_1 \times Treat_i \times Post_t + \sum Controls_{it} + Firm\ FE + Year\ FE + \varepsilon_{it} \quad (1)$$

- $Intensity_{it}$ (H1a): the natural logarithm of yearly emissions of carbon dioxide scaled by sales
- $Emission_{it}$ (H1b): the natural logarithm of yearly emissions of carbon dioxide in metric tons

- $Post_t$: an indicator variable equal to one for fiscal year 2021, and zero otherwise
- $Treat_i$: an indicator variable equal to one for firms that complied with the regulation, and zero otherwise
- Controls: firm size, asset intensity, price-to-book ratio, and leverage

Coarsened exact matching (CEM)

- Treatment and control firms are fundamentally different in their carbon reduction behaviors.
- Match treatment and control firms based on their carbon emissions and intensity at the beginning of the sample period, which proxy for their carbon reduction incentives.
- Within the matched sample, β_1 is less affected by the treatment firms' pre-existing carbon reduction behavior and reflects only the effect of the disclosure regulation.

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Research Design – Measuring Institutional Support

- Human capital support: availability of authorized verification agencies
- *Personnel* = $\frac{Number\ of\ authorized\ agencies}{Regional\ GDP}$
- Manually collected from government websites. GDP is from CSMAR.

	Number of authorized carbon verification agencies	GDP (in trillion RMB)	Personnel score
Ningxia	8	0.39	20.41
Qinghai	6	0.30	19.96
Guizhou	20	1.78	11.22
Heilongjiang	15	1.37	10.95
Shenzhen	22	2.76	7.97
Gansu	7	0.90	7.76
Shanxi	13	1.77	7.36
Beijing	25	3.61	6.92
…	…	…	…
Zhejiang	11	6.46	1.70
Anhui	6	3.87	1.55
Sichuan	6	4.86	1.23
Henan	6	5.50	1.09
Liaoning	2	2.51	0.80
Jiangsu	4	10.27	0.39
Shaanxi	1	2.62	0.38
Tibet	0	0.19	0.00

Research Design – Measuring Institutional Support

- Subsidy: number of carbon-reduction subsidy policies
- *Subsidy* = ln(1+number of subsidy policies issued by all levels of government agencies where the firm is headquartered)
- Manually collected from PKULaw.com

Province	Number of policies	City	Number of policies	County	Number of policies
Henan	7	Shenzhen, Guangdong	12	Changning District, Shanghai	3
Anhui	4	Guangzhou, Guangdong	5	Free Trade Zone, Shanghai	1
Fujian	4	Jincheng, Shanxi	3	Jing'an District, Shanghai	1
Guangdong	4	Lanzhou, Gansu	3	Jingxi, Baise, Guangxi	1
Inner Mongolia	4	Sanya, Hainan	3	Xilin, Baise, Guangxi	1
Chongqing	3	Changzhou, Jiangsu	2	Zhabei District, Shanghai	1
Hebei	3	Chengdu, Sichuan	2		
Jiangxi	3	Hangzhou, Zhejiang	2		
Ningxia	3	Nanchang, Jiangxi	2		
Shandong	3	Ningbo, Zhejiang	2		
Tianjin	3	Ordos, Inner Mongolia	2		
…		…			

Research Design – Measuring Policy Support

- Financial support: implementation of “re-lending” policy
  - “Re-lending” is a monetary policy used by the Chinese central bank and its provincial branches to provide low-cost credit loans to commercial banks to subsidize their lending.
  - The low interest rates and prolonged repayment cycles of such central-bank loans encourages commercial banks to fund green projects.
  - We use the availability of the re-lending tool at the provincial level as an indicator of the financial backing for carbon reduction initiatives.

Province	City	County
Anhui	Ankang, Shaanxi	Xinghua, Jiangsu
Beijing	Huangshi, Hubei	
Chongqing	Xianning, Hubei	
Fujian	Yangzhou, Jiangsu	
Gansu		
Guangdong		
Guangxi		
Guizhou		
Hainan		
Jiangxi		
Qinghai		
Shanghai		
Sichuan		
Tianjin		
Xinjiang		
Zhejiang		

- *GreenFinance* = 1 if a province has re-lending support for green projects by the end of 2021 and 0 otherwise.
  - Obtain data from the 2020 and 2021 *Annual Report on the Development of Local Green Finance in China.*

Research Design for H2

$$Carbon_{it} = \beta_0 + \beta_1 \times Treat_i \times Post_t \times InstSupport_i + \beta_2 \times Treat_i \times Post_t +$$

$$\beta_3 \times Post_t \times InstSupport_i + \sum Controls_{it} + Firm\ FE + Year\ FE + \varepsilon_{it} \quad (2)$$

- $Personnel_i$: Number of authorized carbon verification agencies in a firm's headquarter region, scaled by regional GDP (trillion RMB).
- $Subsidy_i$: Natural logarithm of one plus the number of carbon-reduction subsidy policies in a firm's headquarter county by end of 2021.
- $GreenFinance_i$: An indicator variable equal to one if a firm's headquarter region provides re-lending support for green projects by the end of 2021, and zero otherwise.
- $InstSupport_i$: Sum of three indicators—*Personnel* above median (1/0), *Subsidy* above median (1/0), *GreenFinance* greater than zero (1/0), and takes the value of 0, 1, 2, or 3.

Data

- Chinese listed firms, 2018-2021
- Emissions data for CSI 800 firms: QuantData
- Firm disclosure on carbon reduction: manually collected from annual reports
- Controls: CSMAR

Step	Firm years	Unique firms
CSI 800 firms with non-missing carbon emissions data between 2018-2021	2750	768
Less: firm-years with missing control data	(122)	(2)
Less: firms without at least one observation before and after implementation of the disclosure regulation	(114)	(98)
Less: firms with drastic changes in carbon intensity	(134)	(35)
CSI 800 sample	2380	633
Less: firms that cannot be matched in CEM	(419)	(141)
Final sample	1961	492

Descriptive Statistics (Table 3 Panel A)

The CEM-matched firms have less carbon dioxide both in terms of the absolute amount and intensity, indicating that some firms with high emissions are dropped in the matching process due to the lack of common support.

	CEM-matched sample, N=1961					CSI 800 sample, N=2380				
	Mean	SD	Min	Median	Max	Mean	SD	Min	Median	Max
Intensity	-6.514	2.148	-11.074	-6.711	-.052	-6.322	2.282	-11.074	-6.468	-.052
Emissions	9.819	2.730	3.841	9.692	18.463	10.132	3.044	3.841	9.875	18.463
Treat	.629	0.483	0	1	1	.655	0.476	0	1	1
Size	17.189	0.878	15.675	17.019	20.323	17.302	0.935	15.675	17.104	20.323
AssetIntensity	.192	0.177	.001	.141	.715	.195	0.179	.001	.144	.715
PB	3.11	3.185	.276	1.948	17.332	3.371	3.715	.272	1.967	20.328
Leverage	.49	0.206	.067	.492	.929	.495	0.212	.067	.499	.929
InstSupport	1.715	1.002	0	2	3	1.709	0.991	0	2	3
Personnel	3.706	2.590	0	3.249	11.219	3.791	2.695	0	3.359	20.405
Subsidy	1.398	0.648	0	1.386	2.833	1.381	0.636	0	1.386	2.833
GreenFinance	.694	0.461	0	1	1	.693	0.461	0	1	1

Main Results: H1 (Table 4)

The disclosing firms reduce their emissions per yuan of sale by 7.5% (1 - exp(-0.078)),

and carbon emissions by 8.6% (1 - exp(-0.09)) on average in response to the disclosure regulation.

	CEM-matched sample		CSI 800 sample	
	Intensity	*Emissions*	*Intensity*	*Emissions*
	(1)	(2)	(3)	(4)
Treat × Post	-.078**	-.09*	-.071**	-.097**
	(-2.008)	(-1.888)	(-2.25)	(-2.554)
Size	-.013	.463***	-.021	.484***
	(-.318)	(5.987)	(-.596)	(7.361)
AssetIntensity	.08	.391	.023	.392
	(.3)	(1.071)	(.115)	(1.495)
PB	-.002	-.061***	.001	-.051***
	(-.281)	(-4.186)	(.225)	(-3.884)
Leverage	-.187	.802**	.019	.887***
	(-.83)	(2.32)	(.114)	(3.821)
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Constant	-5.845***	2.02	-5.971***	1.352
	(-7.632)	(1.447)	(-9.657)	(1.178)
Observations	1961	1961	2380	2380
R^2	.008	.3	.005	.328

Main Results: H2 (Table 5 Panel A)

- Treatment firms experience greater carbon reductions in response to the disclosure regulation when they receive more institutional support.
- Carbon intensity from treatment firms slightly increases when there is no additional institutional support.

	Intensity	*Emissions*
	(1)	(2)
Treat × *Post* × *InstSupport*	-.108***	-.118**
	(-2.755)	(-2.239)
Treat × *Post*	.121*	.132
	(1.741)	(1.333)
Post × *InstSupport*	.085**	.107**
	(2.508)	(2.243)
Controls	Yes	Yes
Firm & year fixed effects	Yes	Yes
Constant	-5.851***	1.993
	(-7.726)	(1.442)
Observations	1961	1961
R^2	.018	.307

Main Results: H2 (Table 5 Panel B)

All types of institutional support are effective in helping firms reduce carbon intensity (emissions).

	Intensity	*Emissions*	*Intensity*	*Emissions*	*Intensity*	*Emissions*
	(1)	(2)	(3)	(4)	(5)	(6)
Treat × *Post* × *Personnel*	-.032**	-.036**				
	(-2.261)	(-2.353)				
Treat × *Post* × *Subsidy*			-.101*	-.114*		
			(-1.731)	(-1.775)		
Treat × *Post* × *GreenFinance*					-.216***	-.211**
					(-2.926)	(-2.199)
Treat × *Post*	.042	.046	.078	.1	.085	.072
	(.666)	(.59)	(.884)	(.897)	(1.421)	(.921)
Post × *Personnel*	.019	.022*				
	(1.631)	(1.728)				
Post × *Subsidy*			.082	.138***		
			(1.566)	(2.617)		
Post × *GreenFinance*					.168***	.186**
					(3.213)	(2.279)
Controls & FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1961	1961	1961	1961	1961	1961
R^2	.014	.304	.013	.306	.016	.304

Falsification Tests (Table 6, Panel A)

- Carbon-intensive firms may have been reducing emissions in response to the “dual carbon” policy goals announced in 2020, resulting in carbon reductions in 2021.
- $MDA2020_i$ equal to one if a firm mentioned “carbon peak”, “carbon neutrality”, or “dual carbon” in the MD&A section of its annual report for fiscal year 2020, and zero otherwise.

	Intensity	*Emissions*
	(1)	(2)
MDA2020 × Post	.012	.033
	(.25)	(.65)
Controls	Yes	Yes
Firm & year fixed effects	Yes	Yes
Constant	-4.12***	4.682***
	(-4.258)	(4.797)
Observations	1556	1556
R^2	.01	.317

Falsification Tests (Table 6, Panel B)

- The political pressure for local governments to reduce carbon emissions may drive both the level of institutional support and local firms' carbon emissions.
- $Target_i$ is the intended percentage of reduction in greenhouse gas emissions for a region announced in the 13th Five-Year Plan (2016-2020).

	(1) *Intensity*	(2) *Emissions*	(3) *Intensity*	(4) *Emissions*
Treat × *Post* × *Target*	-.007	.033	.021	.068
	(-.309)	(.71)	(1.018)	(1.487)
Treat × *Post* × *InstSupport*			-.117***	-.141***
			(-2.9)	(-2.734)
Treat × *Post*	.064	-.754	-.272	-1.192
	(.15)	(-.804)	(-.715)	(-1.303)
Post × *Target*	.015	-.022	-.008	-.054
	(.803)	(-.512)	(-.484)	(-1.29)
Post × *InstSupport*			.087**	.123***
			(2.528)	(2.631)
Controls	Yes	Yes	Yes	Yes
Firm & year fixed effects	Yes	Yes	Yes	Yes
Constant	-5.874***	2.015	-5.864***	2.01
	(-7.677)	(1.449)	(-7.726)	(1.455)
Observations	1961	1961	1961	1961
R^2	.009	.301	.019	.309

Carbon Management Experience (Table 7)

- Institutional support is particularly important to firms lacking prior carbon management experience.
- We identify experienced firms by their participation in the carbon emissions trading system (ETS).

Inexperienced firms

	Intensity (1)	*Emissions* (2)	*Intensity* (3)	*Emissions* (4)	*Intensity* (5)	*Emissions* (6)
Treat × Post × Personnel	-.053***	-.061***				
	(-2.769)	(-2.686)				
Treat × Post × Subsidy			-.137*	-.266***		
			(-1.718)	(-2.988)		
Treat × Post × GreenFinance					-.196**	-.169
					(-2.342)	(-1.336)
Treat × Post	.146**	.219**	.164	.405***	.095	.127
	(2.09)	(2.416)	(1.525)	(2.942)	(1.563)	(1.201)
Post × Personnel	.036**	.047**				
	(2.14)	(2.264)				
Post × Subsidy			.122*	.269***		
			(1.708)	(3.559)		
Post × GreenFinance					.106*	.144
					(1.779)	(1.298)
Controls & FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1593	1593	1593	1593	1593	1593
R^2	.021	.324	.015	.336	.012	.314

Experienced firms

Intensity (1)	*Emissions* (2)	*Intensity* (3)	*Emissions* (4)	*Intensity* (5)	*Emissions* (6)
-.032	.01				
(-.824)	(.192)				
		-.113	.184		
		(-.675)	(.879)		
				-.338**	-.549***
				(-2.339)	(-2.78)
-.074	-.42	-.003	-.701	.024	.036
(-.298)	(-1.149)	(-.007)	(-1.363)	(.245)	(.246)
.016	-.022				
(.438)	(-.455)				
		.107	-.109		
		(.667)	(-.558)		
				.303**	.459**
				(2.469)	(2.481)
Yes	Yes	Yes	Yes	Yes	Yes
320	320	320	320	320	320
.091	.349	.089	.352	.101	.363

Robustness Tests

- Parallel trends
- Addressing the alternative explanation of national ETS
- Adjustments in CEM
  - Increase the number of bins
  - Matching on additional firm characteristics
  - Carbon management rating score

Conclusions

- The disclosure regulation reduces carbon intensity and emissions only for firms benefiting from public investment in establishing knowledge, skills, and green financing infrastructure.

- Contributes to the literature on the real effects and the limitations of ESG-related disclosure regulations.

- Policy implications: disclosure regulations intended to reduce carbon emissions should be accompanied by other supporting policies.