# How Does Made in China 2025 Strategy Influence Green Innovation? A Quasi-Natural Experiment of Chinese Firms

**Running Title: Industrial Policy Intervention and Corporate Green Innovation**

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# Presentation Outline

1. Background
2. Objectives
3. Analytical Framework
4. Empirical Results and Research Direction

# Background

Industrial policy is usually defined as addressing structural change of the economy – sustained rapid industrialization.

China industrial development is not only due to market-oriented reform and a more open domestic market, but also due to the correct industrial development strategy and the changing industrial policies.

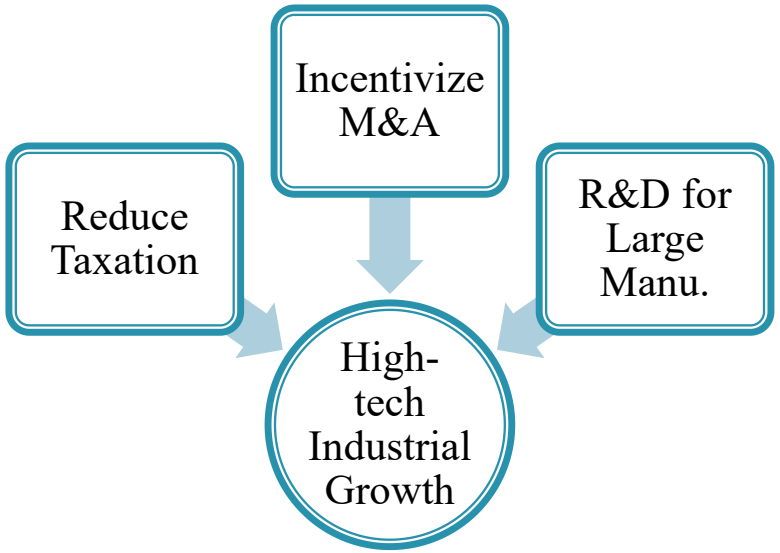
Four stages: system transition period (1978 - 1991), the period of initial establishment of market economy system (1992-2001), the period from China's accession to WTO to the 18th National Congress of the CPC (2001-2012) and the period since the 18th National Congress (2012-2019)

**Made in China 2025 (MIC)**

**Implemented in 2015**

- **Leading Position in Manufactur..**
  - **Pilot cities: Local governments.**
  - **10 Core Industries**
  - **Core Material Target (70% by 2025)**
- **World Factory to Technology powerhouse**
  - **High tech- Industry**
  - **Smart Manufacturing**
  - **Independence from foreign suppliers**

MIC 2015




MIC 2025 in 2015 is highly institutionalized techno industrial policy, which targets key technologies and sectors in the next ten years. The new policy is consistent with the goal of "indigenous innovation"

**13th (2016-2020) and 14th (2021-2025) Five-year plans**

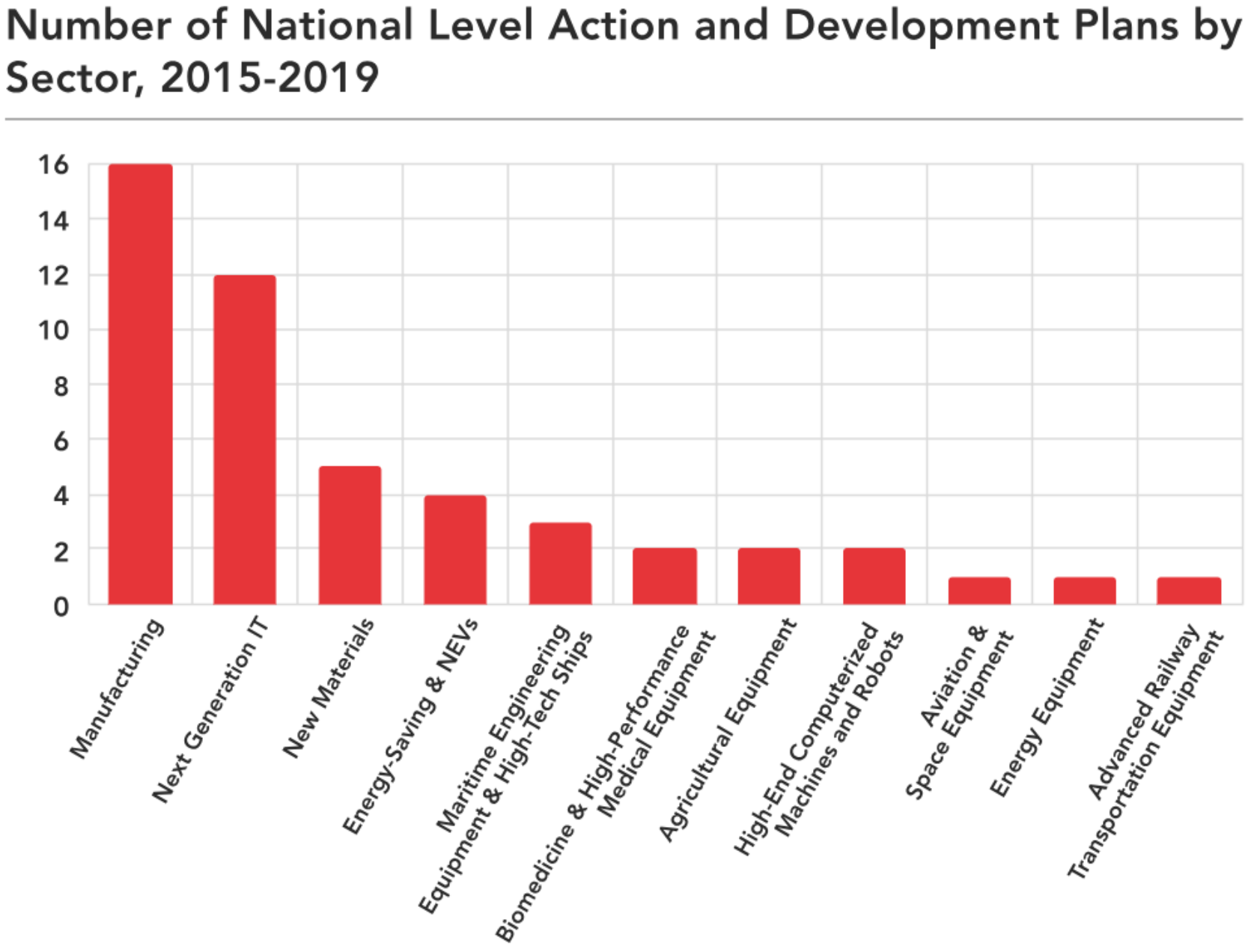
- Innovation driven growth
- low-carbon development
- Reeducation in carbon intensity

Green industrial transformation and energy transition are two fundamental objectives of 13$^{th}$ and 14$^{th}$ five years plans.

# Background


WHAT IS 'MADE IN CHINA 2025'?
A strategic plan by the Chinese government to transform the country into a global high-tech powerhouse across 10 key sectors:
New energy vehicles
Electrical equipment
Numerical control machinery and robotics
Aerospace and aviation equipment
Agricultural machinery and equipment
Railway equipment
New information technology
New materials
Biopharmaceuticals and medical devices
Maritime engineering equipment and high-tech vessels

# Background




China's total expenditure on research and development (R&D) amounted to nearly 3.09 trillion yuan (about 456 billion U.S. dollars, 2.55% of GDP) in 2022, up 10.4 percent year on year, according to the National Bureau of Statistics

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*77% to Business,
*7% to Universities
*16% to Government

# Objectives

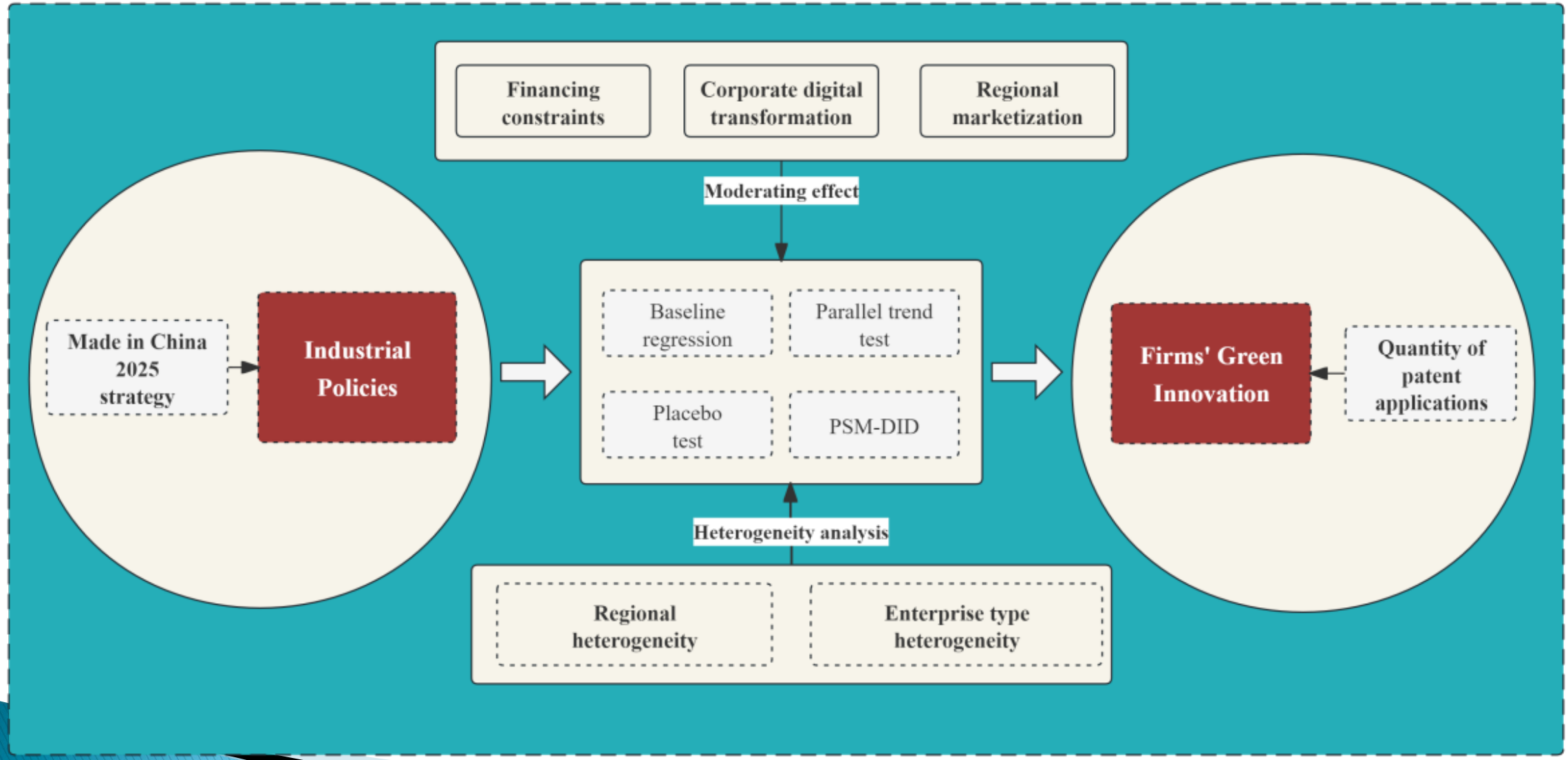
To assess the impact of the “MIC" strategy on firms' green innovation using a natural quasi-experiment.

To examine regional/industrial disparities in the influence of industrial policies on green innovation.

To analyze the role of *financing constraints,* digital transformation, and marketization in moderating the effects of MIC on green innovation

To analyze the other factors of corporate green innovation and lesson for peer countries

# Analytical Framework



# Analytical Framework: Sample

Cathay Pacific (CSMAR) data set explored
Unbalanced panel from 2000 to 2021,

Companies in the financial category are excluded
Samples of companies:
-ST, *ST, or PT during the observation period are excluded
-Companies that are missing the main variables are excluded

1,594 firms are selected for the study 815 treated and 779 control group
Observations ranged from 8850 to 10538

# Analytical Framework: Sample Sample Industry Catagories

| Industry Classification | # of total firms | # treat group | # control group |
|---|---|---|---|
| A. Agriculture and Livestock | 19 | 0 | 19 |
| B. Mining | 62 | 0 | 62 |
| **C.Manufacturing** | **966** | **815** | **151** |
| D. Energy and water production and supply | 70 | 0 | 70 |
| E. Construction | 45 | 0 | 45 |
| F. Wholesale and retail trade | 90 | 0 | 90 |
| G. Transportation, storage and postal services | 64 | 0 | 64 |
| H. Accommodation and catering | 6 | 0 | 6 |
| I. Information transmission, software and information technology services | 82 | 0 | 82 |
| K.Real Estate | 72 | 0 | 72 |
| L. Rental and business services | 27 | 0 | 27 |
| N. Water conservancy, environment and public facilities management industry | 16 | 0 | 16 |
| O. Residential Services, Repair and Other Services | 19 | 0 | 19 |
| P. Education | 2 | 0 | 2 |
| Q.Health and social work | 1 | 0 | 1 |
| R.Culture, sports and recreation | 8 | 0 | 8 |
| S. Public administration, Social security and social organizations | 45 | 0 | 45 |
| **Total** | **1594** | **815** | **779** |

# Analytical Framework: Sample Treat Group Sectors

| Industry Code | Industry Name | Number of enterprises |
|---|---|---|
| C26 | Chemical raw materials and chemical products manufacturing | 106 |
| C27 | Pharmaceutical Manufacturing | 103 |
| C28 | Chemical fiber manufacturing | 15 |
| C29 | Rubber and plastic products industry | 20 |
| C30 | Non-metallic mineral products industry | 40 |
| C31 | Ferrous metal smelting and rolling processing industry | 25 |
| C32 | Non-ferrous metal smelting and rolling processing industry | 43 |
| C33 | Metal Products Industry | 20 |
| C34 | General Equipment Manufacturing | 43 |
| C35 | Specialty Equipment Manufacturing | 75 |
| C36 | Automobile Manufacturing | 45 |
| C37 | Railroad, ship, aerospace and other transportation equipment manufacturing industry | 30 |
| C38 | Electrical machinery and equipment manufacturing | 95 |
| C39 | Computer, communications and other electronic equipment manufacturing | 140 |
| C40 | Instrumentation Manufacturing | 15 |
| | **Total** | 815 |

# Analytical Framework: Sample 10 key sectors

| Name of key sectors involved | Industry codes involved | Number of enterprises |
|---|---|---|
| Railroad Equipment | C37+C40 | 45 |
| New Energy Vehicles | C36 | 45 |
| New Information Technology | C39 | 140 |
| Electrical Equipment | C38 | 95 |
| New Materials | C26+C28+C29+C30+C31+C32+C33 | 269 |
| CNC Machinery and Robotics | C35 | 75 |
| Biopharmaceuticals and Medical Devices | C27 | 103 |
| Aerospace Equipment | `- | - |
| Agricultural machinery and equipment | C34 | 43 |
| **Total** | | **815** |

# Analytical Framework: Model

Foundational model is as follows:

$$CGI_{it} = \alpha + \beta treat_i \times post_t + \gamma X_{it} + \delta_t + \mu_i + ind_k + \varepsilon_{it} \quad (1)$$

The explanatory variable $CGI_{it}$ is the green innovation level of enterprise $i$ in year $t$. $treat_i$ is a dummy variable for the experimental group, which takes 1 if enterprise $i$ is a pilot enterprise and 0 otherwise. $post_t$ is a dummy variable for the experimental period, which takes 1 in 2015 and after, and 0 before 2015.

$\beta$ is the parameter of interest in this paper, whose sign and value represent the direction and magnitude of the impact of implementing the "Made in China 2025" industrial policy on corporate green innovation. $\beta$ is the parameter of interest in this paper, whose sign and value represent the direction and size of the impact of implementing the "Made in China 2025" industrial policy on enterprises' green innovation. $X_{it}$ is the control variable included in this paper. Meanwhile, this paper controls for the time-fixed effect ($\delta_t$), individual fixed effect ($u_i$), and industry-fixed effect ($ind_k$), and $\varepsilon_{it}$ is the random error term.

# Analytical Framework: Variables

**Dependent variable:** Corporate green innovation (CGI) is the # of enterprise green development patent applications (approved)

**Independent variable: E**mploys group dummy variables and staged dummy variables within the framework of a quasi-natural experiment, based on the initiation of the "Made in China 2025" industrial policy in 2015.

To establish the experimental and control groups, grouping dummy variables are employed, denoted as "Treat." Companies falling within MIC focal areas are classified as the experimental group, represented by a value of 1 for Treat. Conversely, companies outside these areas are assigned to the control group, with a Treat value of 0.

The staging dummy variable is denoted as "Post." A year subsequent to 2015 indicates the implementation phase of the strategy, assigning a value of 1 to Post. Conversely, a year preceding the implementation denotes a value of 0 for Post.

# Analytical Framework: Variables

**Control variables**

To avoid estimation bias caused by omitted variables, the following control variables are introduced concerning the studies of scholars such as (Pan et al., 2022; Xu et al., 2023):

firm size (*Ta*), expressed in terms of total assets, number of employees in the firm (*Ne*), total profits of the firm (*Tp),* turnover of total assets (*Ato*), net profit margin of total assets (*Roa*), return on net assets (*Roe*), Tobin's Q (*Tbq*), and the percentage of shares held by the first largest shareholder (*Sha*).

# Analytical Framework: Variables

**Mechanism Variables:**

**Financing constraints (SA):** The present study selects the exogenous SA index (Hadlock & Pierce, 2010) as the preferred measure for capturing enterprises' financing constraints. Below equation demonstrates the calculation method employed, where SA denotes the firm's financing constraint, Size represents the logarithm of the firm's assets, and Age indicates the number of years the firm has been listed.

$$SA=-0.737\times Size+0.043\times Size^2-0.04\times Age$$

**Corporate digital transformation :** Following Wu et al. (2022), it analyse word frequency statistics encompassing the term "enterprise digital transformation" found in the annual reports of listed companies using web crawling.

**Regional marketization:** Adopts the relevant index compiled by Fan et al. (2011) as a metric for assessing the level of marketization. The selected index serves as a representative measure of the quality of the external governance environment, with larger values indicating a more favorable regional market environment.

# Analytical Framework: Method

MIC industrial policy focuses on industries with well-defined boundaries, and the interval between its introduction and implementation is relatively short, thereby serving as an exogenous policy shock to enterprises and creating favorable conditions for employing the Difference-in-Differences (DID) model.

**D-DID** is an advanced econometric technique used to estimate the causal effect of a treatment or intervention when multiple groups are exposed to the treatment at different times. It builds upon the traditional Difference-in-Difference (DID) approach by introducing an additional time dimension or treatment group, allowing for more complex comparisons.

The study will employ a **double-difference-in-difference (D-DID)** model to estimate the impact of industrial policies on firms' green innovation.

**Parallel trend assumption:** The difference in the means of the explanatory variables between the experimental and control groups remains consistent across time. It requires that the time trends of the explanatory variables in both groups exhibit a consistent pattern.

# Empirical Results

**Descriptive Statistics**

| Classification | Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Dependent variable | *CGI* | 3.80 | 25.46 | 0.00 | 996 |
| Independent variables | *treat* | 0.52 | 0.50 | 0.00 | 1.00 |
| | *post* | 0.69 | 0.46 | 0.00 | 1.00 |
| Control variables | *Ta* | 22.30 | 1.67 | 16.52 | 31.31 |
| | *Ne* | 7.76 | 1.44 | 2.08 | 13.13 |
| | *Tp* | 15.33 | 105.37 | -244.97 | 4248.99 |
| | *Ato* | 0.62 | 0.52 | 0.00 | 8.25 |
| | *Roe* | 0.06 | 3.00 | -53.96 | 281.99 |
| | *Roa* | 0.03 | 0.15 | -3.99 | 2.64 |
| | *Tbq* | 2.05 | 3.29 | 0.68 | 122.19 |
| | *Sha* | 36.06 | 16.21 | 0.39 | 98.86 |
| Mechanism variables | *SA* | -3.80 | 0.30 | -5.32 | -2.11 |
| | *DT* | 10.45 | 28.46 | 0.00 | 544 |
| | *MAR* | 9.088 | 1.74 | -0.16 | 11.49 |

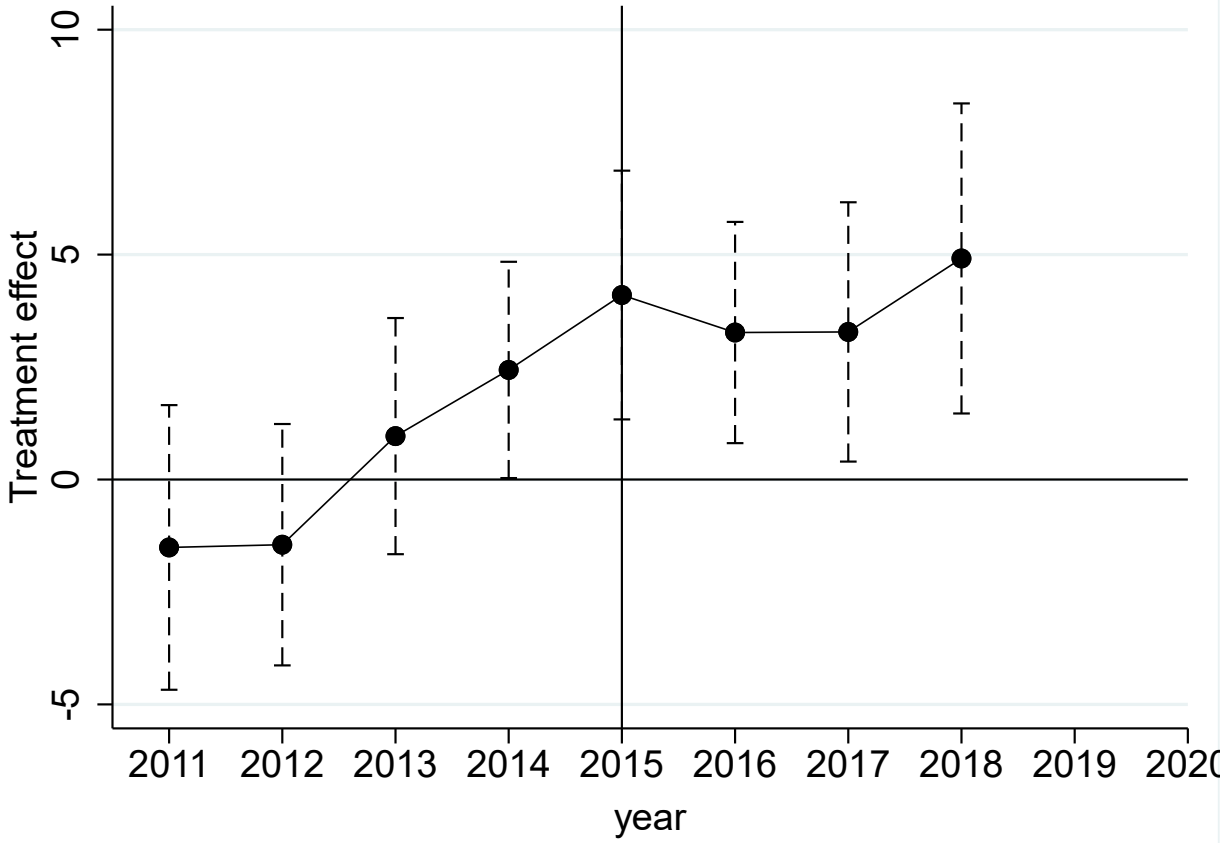
# Empirical Results- Baseline Regression

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | *CGI* | *CGI* | *CGI* | *CGI* |
| *post ×treat* | 4.613*** | 4.634*** | 0.915** | 1.168* |
| | (0.527) | (0.529) | (0.430) | (0.693) |
| *Ta* | | 1.008*** | -0.159 | -0.159 |
| | | (0.245) | (0.226) | (0.240) |
| *Ne* | | 0.919*** | 0.142 | 0.153 |
| | | (0.271) | (0.205) | (0.221) |
| *Tp* | | 0.003 | 0.004 | 0.004 |
| | | (0.003) | (0.003) | (0.003) |
| *Ato* | | -0.430 | -0.437 | -0.445 |
| | | (0.525) | (0.355) | (0.365) |
| *Roe* | | 0.077 | -0.043 | -0.042 |
| | | (0.283) | (0.042) | (0.043) |
| *Roa* | | -0.987 | 1.404 | 1.344 |
| | | (3.341) | (1.693) | (1.718) |
| *Tbq* | | 0.054 | 0.027 | 0.028 |
| | | (0.095) | (0.025) | (0.026) |
| *Sha* | | -0.016 | 0.027 | 0.029 |
| | | (0.017) | (0.021) | (0.022) |
| *Constant* | 1.704*** | -27.275*** | 5.070 | 4.838 |
| | (0.365) | (4.497) | (4.310) | (4.599) |
| *Firm/Year* | No | No | YES | YES |
| *Firm/Ind/Year* | No | No | No | YES |
| *R-squared* | 0.008 | 0.019 | 0.669 | 0.667 |

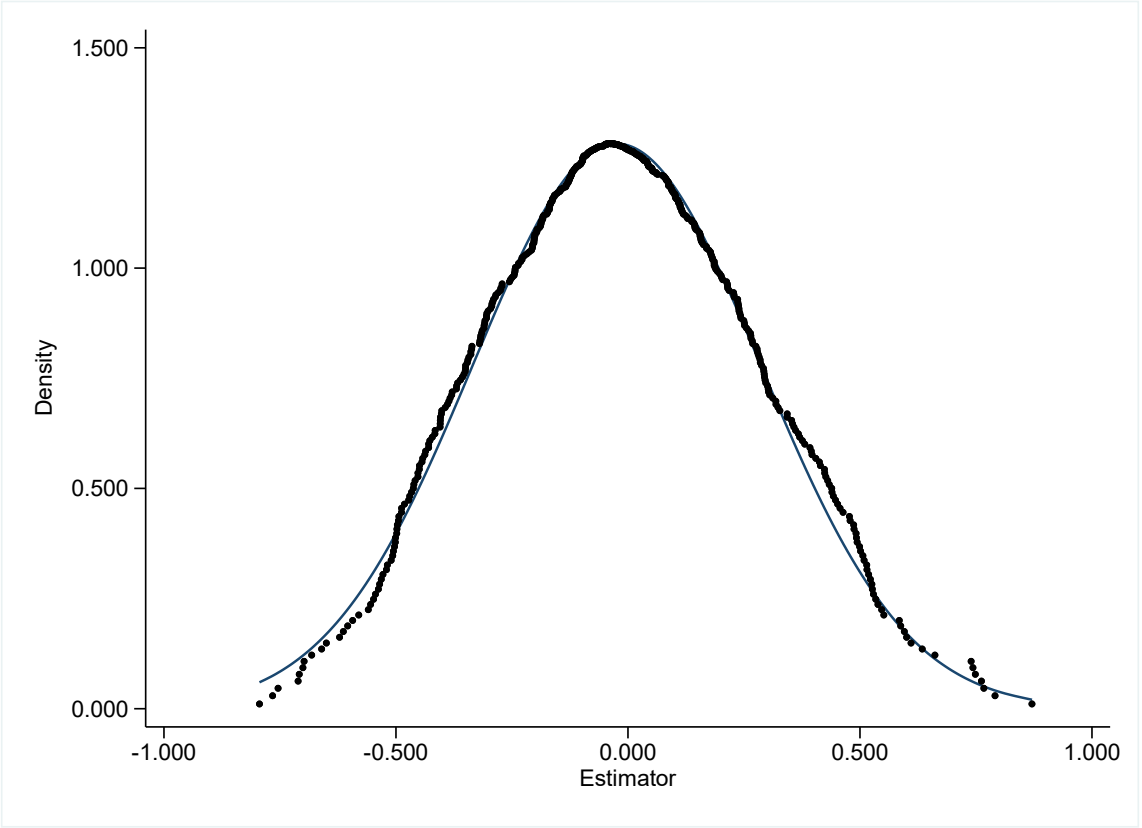
Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01。

# Empirical Results-Prerequisite Tests

## Parallel Trend Test




## Placebo Test



# Empirical Results-Prerequisite Tests

**Counterfactual testing**

| | (1) | (2) |
|---|---|---|
| | *CGI* | *CGI* |
| *post×treat_2012* | 0.824 | 0.913 |
| | (0.700) | (0.701) |
| *Control* | No | YES |
| *Firm/Ind/Year effect* | YES | YES |
| *Constant* | 3.564*** | 4.992 |
| | (0.363) | (4.600) |
| *Observations* | 9514 | 9514 |
| *R-squared* | 0.667 | 0.667 |

# Empirical Results-DID Model

**Average treatment effect estimation results**

| Variable | ATT | Standard error | t-value |
|---|---|---|---|
| *CGI* | 5.518*** | 0.413 | 9.25 |

**Endophytic treatments result**

| | (1) | (2) |
|---|---|---|
| | *Psm-DID* | *Psm-DID* |
| *post ×treat* | 3.343*** | 3.417*** |
| | (0.867) | (0.871) |
| *Control* | No | YES |
| *Firm/Ind/Year effect* | YES | YES |
| *Constant* | 2.731*** | 3.707 |
| | (0.355) | (4.601) |
| *Observations* | 9508 | 9508 |
| *R-squared* | 0.668 | 0.668 |

# Empirical Results-Robustness Tests

**Robustness and endogeneity tests**

| VARIABLES | (1) | (2) | (3) |
|---|---|---|---|
| *post×treat* | 3.415*** | 3.822*** | 3.795*** |
| | (0.868) | (0.872) | (0.875) |
| *control variable* | Yes | Yes | Yes |
| *Constant* | 3.710 | 3.352 | 3.300 |
| | (4.591) | (4.641) | (4.672) |
| *Firm/Ind/Year effect* | Yes | Yes | Yes |
| *Firm/Ind/Year/City effect* | No | Yes | No |
| *R-squared* | 0.668 | 0.669 | 0.669 |

- Beijing and Shanghai are excluded (Column 1)
- City-level fixed effects are incorporated as controls (Column 2)
- Additional control variables are included (Column 3)

# Empirical Results-Heterogeneity Results

**External environment heterogeneity results**

| | (1) | (2) |
|---|---|---|
| | **Eastern Region** | **Central and Western Regions** |
| *post×treat* | **1.748*** | **0.346** |
| | **(1.040)** | **(0.278)** |
| **Fisher's permutation test** | -1.402*** | |
| ***Control*** | YES | YES |
| ***Firm/Ind/Year effect*** | YES | YES |
| ***Constant*** | 1.224 | 18.514** |
| | (5.828) | (7.714) |
| ***Observations*** | 6551 | 2957 |
| ***R-squared*** | 0.677 | 0.538 |

# Empirical Results-Heterogeneity Results

**External environment heterogeneity results**

| | (1) | (2) |
|---|---|---|
| | **Lightly polluting enterprises** | **Heavily polluting enterprises** |
| ***post×treat*** | **2.381*** | **-0.004** |
| | **(1.304)** | **(0.298)** |
| **Fisher's permutation test** | 2.385*** | |
| ***Control*** | YES | YES |
| ***Firm/Ind/Year effect*** | YES | YES |
| ***Constant*** | 7.771 | 4.795 |
| | (5.084) | (10.352) |
| ***Observations*** | 6430 | 3064 |
| ***R-squared*** | 0.649 | 0.789 |

# Empirical Results-Mechanism

| VARIABLES | (1) | (2) | (3) |
|---|---|---|---|
| *post ×treat* | **1.891**** | -0.055 | 1.059 |
| | **(0.957)** | (0.711) | (0.679) |
| *post ×treat ×SA* | **4.516**** | | |
| | **(2.267)** | | |
| *SA* | 13.837*** | | |
| | (4.019) | | |
| *post ×treat ×DT* | | **0.129**** | |
| | | **(0.052)** | |
| *DT* | | 0.070*** | |
| | | (0.025) | |
| *post ×treat ×MAR* | | | **0.692*** |
| | | | **(0.400)** |
| *MAR* | | | -0.516 |
| | | | (0.328) |
| *control variable* | YES | YES | YES |
| *Constant* | 57.576*** | 6.025 | 9.378* |
| | (15.378) | (5.036) | (5.375) |
| *Firm/Ind/Year effect* | YES | YES | YES |
| *R-squared* | 0.668 | 0.670 | 0.667 |

# Results and Explanations

Key Take Aways

- MIC Contributes to corporate green innovation, however, its marginal impact varies at industrial level, regional disparity and nature of firms.
- MIC influence firm's green innovation through removing financing constraints, digital transformation, and increasing regional marketization.

- Prior literature produced mixed outcomes, mainly they studied the MIC impact on firm's performance, productivity, overall R&D input intensity, and financing availability, however no conclusive outcome has been drawn due to various reasons.
- So far, no noticeable study explore its impact on green innovation through unique mechanism

# Future consideration

Further Consideration

- This working paper later would be extended considering foreign spillovers, especially inward FDI spillovers considering specific firms and industries, rather than taking all sectors

- Single firm/industry level case study could be explored to navigate the direct benefits received form MIC 2025 strategy. A comparative analysis of different industrial initiatives could also be considered.

# Recommendations

Recommendations

- **Enhance Industrial Policy Quality**: Shift focus from scale and quantity to improving the quality and productivity of industries. Increase support for advanced manufacturing and enhance resource allocation efficiency to boost green innovation levels.

- **Establish a Green Innovation System:** Develop a comprehensive innovation framework that promotes green innovation. Support enterprises with financial assistance, innovation incentives, and tax benefits to enhance their green competitiveness and sustain industry growth.

# Recommendations

Recommendations

- **Tailor Regional Policies**: Create region-specific industrial policies considering regional disparities and pollution levels. Offer greater support and incentives to enterprises in the eastern regions and those with lower pollution to accelerate their green innovation efforts.

- **Reduce Financing Constraints**: Establish a green finance fund and implement green credit policies to ease financing for green innovation. Encourage digital transformation in enterprises by providing support and training, and strengthen market competition mechanisms to ensure fair practices.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