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Does efficiency-seeking FDI promote sustainable and resilient supply chains?

Firm-level evidence from Thai manufacturing under the Green Industry policy.

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EXECUTIVE SUMMARY

Key message: Efficiency-seeking FDI can strengthen firm resilience and sustainability **when** supported by green policy frameworks and skills → **Institution-Anchor Investment**

Paper focus: Thai manufacturing (2016-2021); interaction of FDI with Green Industry (GI) and Bio-Circular-Green (BCG) policy.

Productivity Premium

FDI ownership enhances labor and TFP growth during shocks.

Green Amplifier

Green Industry certification strongly multiplies FDI resilience effects.

Skill Dependency

Productivity returns rely heavily on skilled-labor intensity.

1. THE ECONOMIC PROBLEM

Efficiency vs. Vulnerability

Recent macro-shocks exposed the fragility of highly concentrated Global Value Chains.

COVID-19: Massive supply-side disruption.

Energy Crisis: Severe input-cost volatility.

The Core Question

Can traditional efficiency-seeking FDI generate durable resilience under stress, or does it merely create fragile efficiency when firms face systematic shocks?

Three contributions to economic literature:

- Measure resilience as firm-level adjustment capacity (Hopenhayn, 1992; Melitz, 2003; Carvalho, 2014)
- Clarify the strategic role of FDI by moving beyond average productivity premia to durable resilience under shocks (Helpman et al., 2004; Alfaro & Chen, 2018)
- Highlight how green industrial institutions can condition the resilience effects of FDI (Porter & van der Linde, 1995; Aghion et al., 2016).

POLICY RELEVANCE

Strategic Alignment in Thailand

BCG Agenda

National strategy transforming industry toward bio-based, circular, and green value chains.

BOI "Go Green"

Targeted tax incentives for green investments and strategic supply chain upgrades.

Green Industry Policy

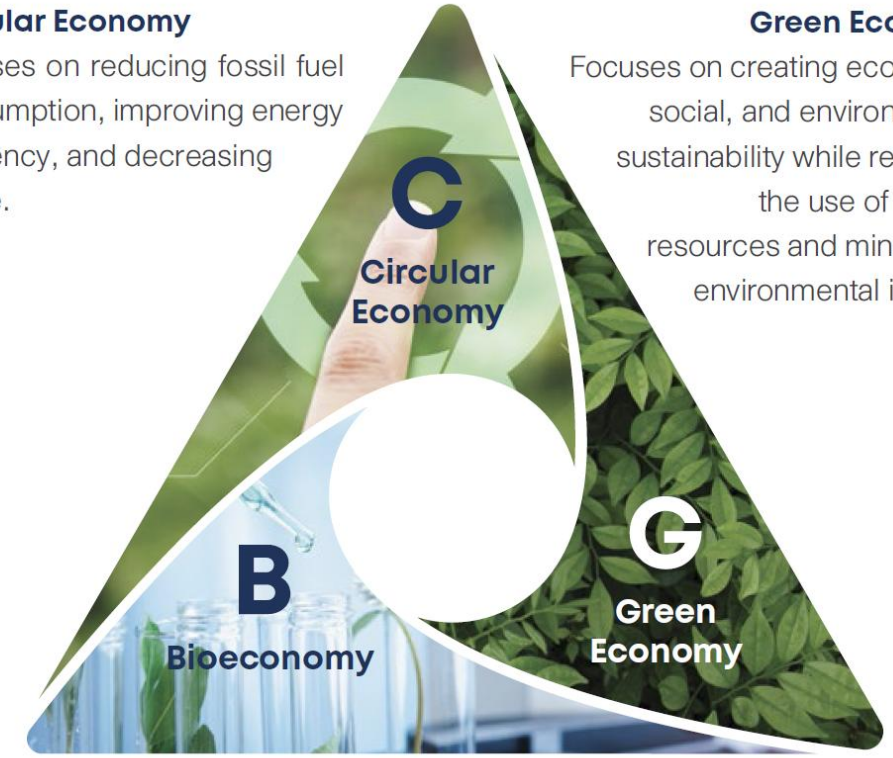
Tiered certification governing factory operations and environmental management.

POLICY RELEVANCE

THAILAND'S STRATEGIC PATH TO ADVANCING THE BIO-BASED INDUSTRY

Circular Economy
Focuses on reducing fossil fuel consumption, improving energy efficiency, and decreasing waste.

Green Economy
Focuses on creating economic, social, and environmental sustainability while reducing the use of natural resources and minimizing environmental impact.



Bioeconomy
The largest component contributing to bio-based industry, which mainly focuses on agriculture, forestry, fisheries, and raw materials for bio-manufacturing products.

Source: BOI Thailand, E&E Industry (2025)
https://www.boi.go.th/upload/content/Brochure_Green%20Industry.pdf

Timelines

2015

Thailand 4.0 and the new s-curve

The S-Curve policy will be a key driver of the Thai economy, focusing on the adoption of technology and innovation.

The "First S-Curve" includes Agriculture and Biotechnology and Food for the Future, while Biofuels and Biochemicals have been added to the "New S-Curve."

2021

BCG Economy Development

The development of Bio-Circular-Green Economy aims at promoting inclusive and sustainable growth. It harnesses the nation's biological diversity and cultural wealth, leveraging technology and innovation. The model focuses on advancing the bioenergy, biomaterial, and biochemical sectors.

2024

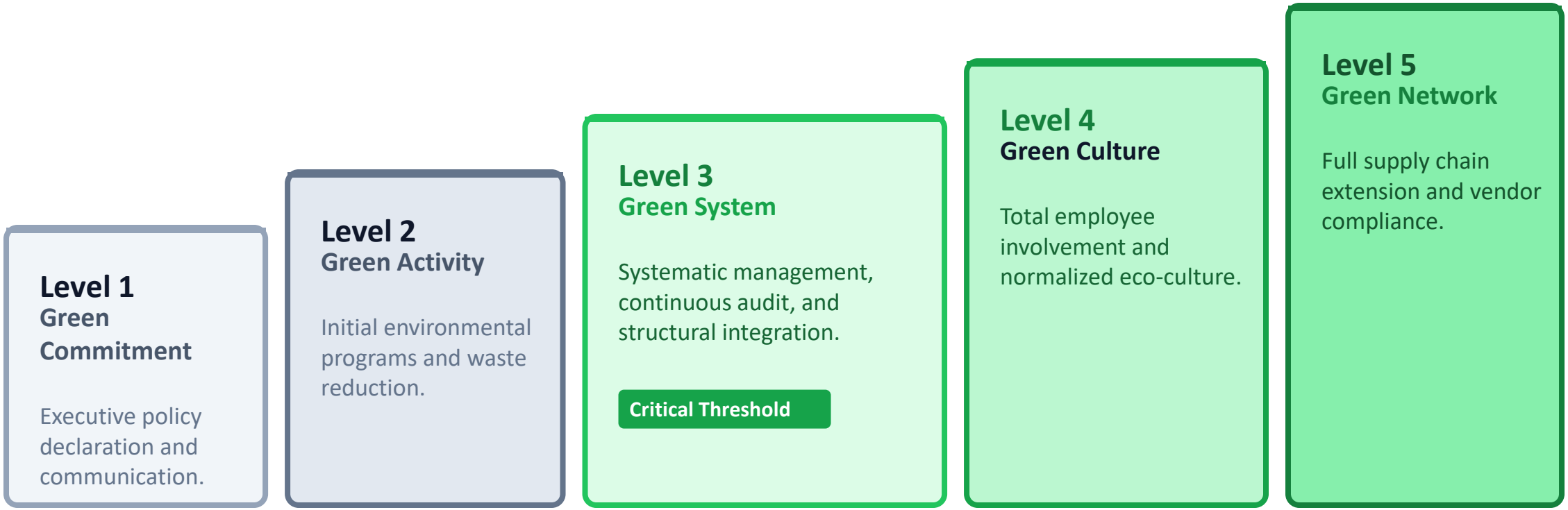
Thailand Vision 2030

The government has set a goal for Thailand to become the global hub for agriculture and food, tourism, and wellness and medical services.

Many measures have been launched to promote bio-based industries through both tax and non-tax incentives.

INSTITUTIONAL FRAMEWORK

Green Industry Certification Tiers



Source: Ministry of Industry, DIW - Thailand (2015)

THE KNOWLEDGE GAP

Moving Beyond Static Measurement

Previous Studies

- ✗ **Static evaluation:** Cross-sectional correlations.
- ✗ **Coarse data:** Binary certification flags.
- ✗ **Selection bias:** Failure to isolate causal resilience.

This Paper's Approach

- ✓ **Dynamic adjustment:** Pre/Post shock panel data.
- ✓ **Tiered treatment:** Analyzing intensity of green compliance.
- ✓ **Causal leverage:** Fixed-effects First Difference

RESEARCH OBJECTIVE

Does efficiency-seeking FDI promote sustainable and resilient supply chains, and does Green Industry policy shape this effect?

Whether and how efficiency-seeking foreign direct investment (FDI) contributes to resilient and sustainable supply chains to better maintain productivity and cost discipline amid disruptions.

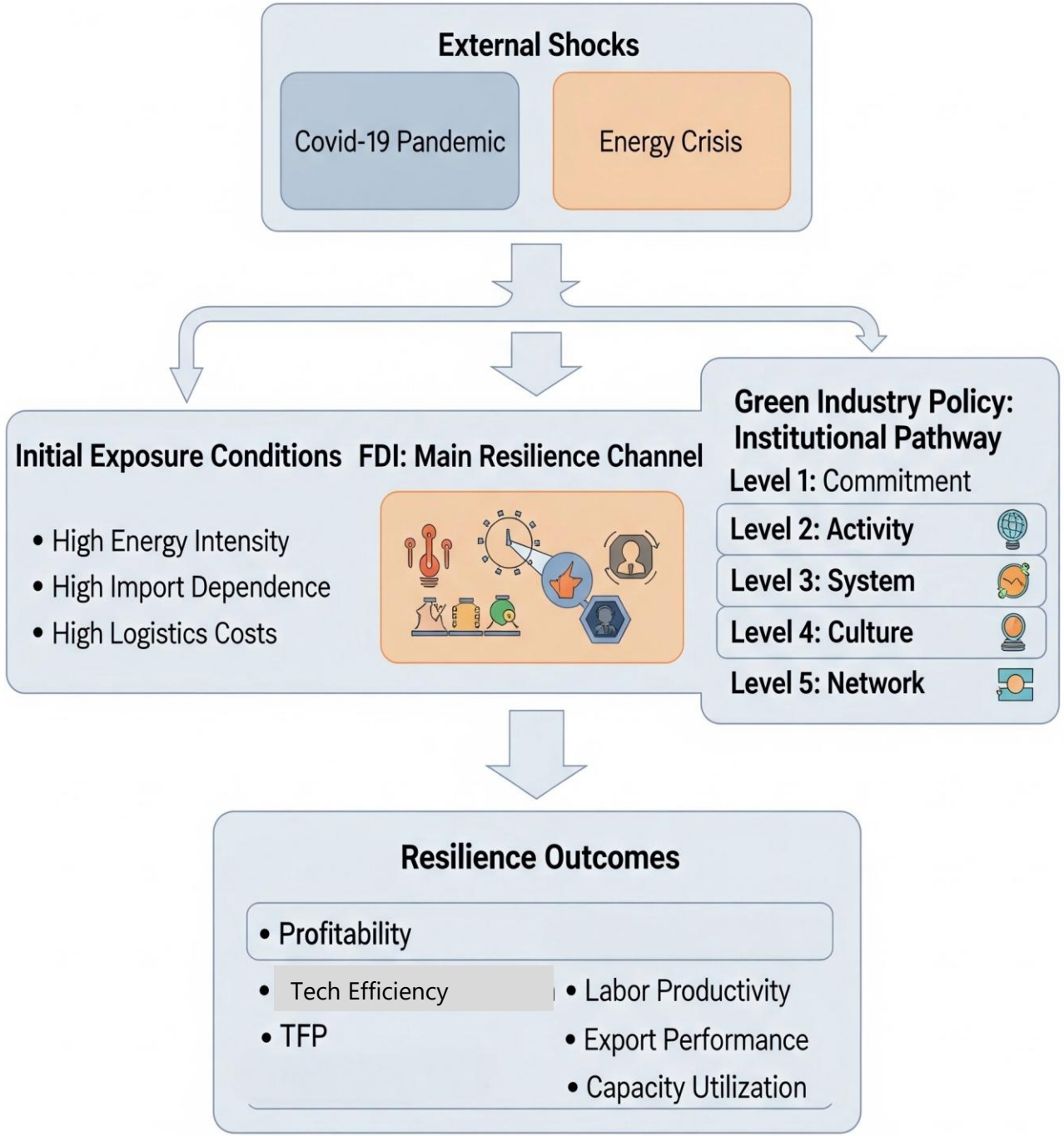
How host-country green industrial institutions condition this relationship

Focus on Thai manufacturing firms between 2016 and 2021

CONCEPTUAL FRAMEWORK

FDI & Institutional Conditioning

- **FDI provides managerial and technological advantages for resilience** (Helpman et al., 2004; Alfaro & Chen, 2018).
- **Institutions determine whether FDI advantages translate into resilience** (North, 1990).
- **Green Industry policy embeds monitoring, management systems, and efficiency targets into firms** (Porter & van der Linde, 1995; Aghion et al., 2016).
- **Productivity gains from green policies are strongest for technologically capable firms** (Berman & Bui, 2001; Albrizio et al., 2017).
- **FDI and Green Industry policy jointly strengthen resilience through institutional alignment** (North, 1990; Aghion et al., 2016)
- Thailand's Green Industry (GI) policy—launched in 2010 following the 2009 Manila Declaration on Green Industry in Asia



CONCEPTUAL FRAMEWORK

External Shocks

COVID-19 Pandemic
Energy Price Crisis

THE AMPLIFIER

FDI Capabilities
+
Green Industry Policy

Institutional Pathway

Resilience Outcomes

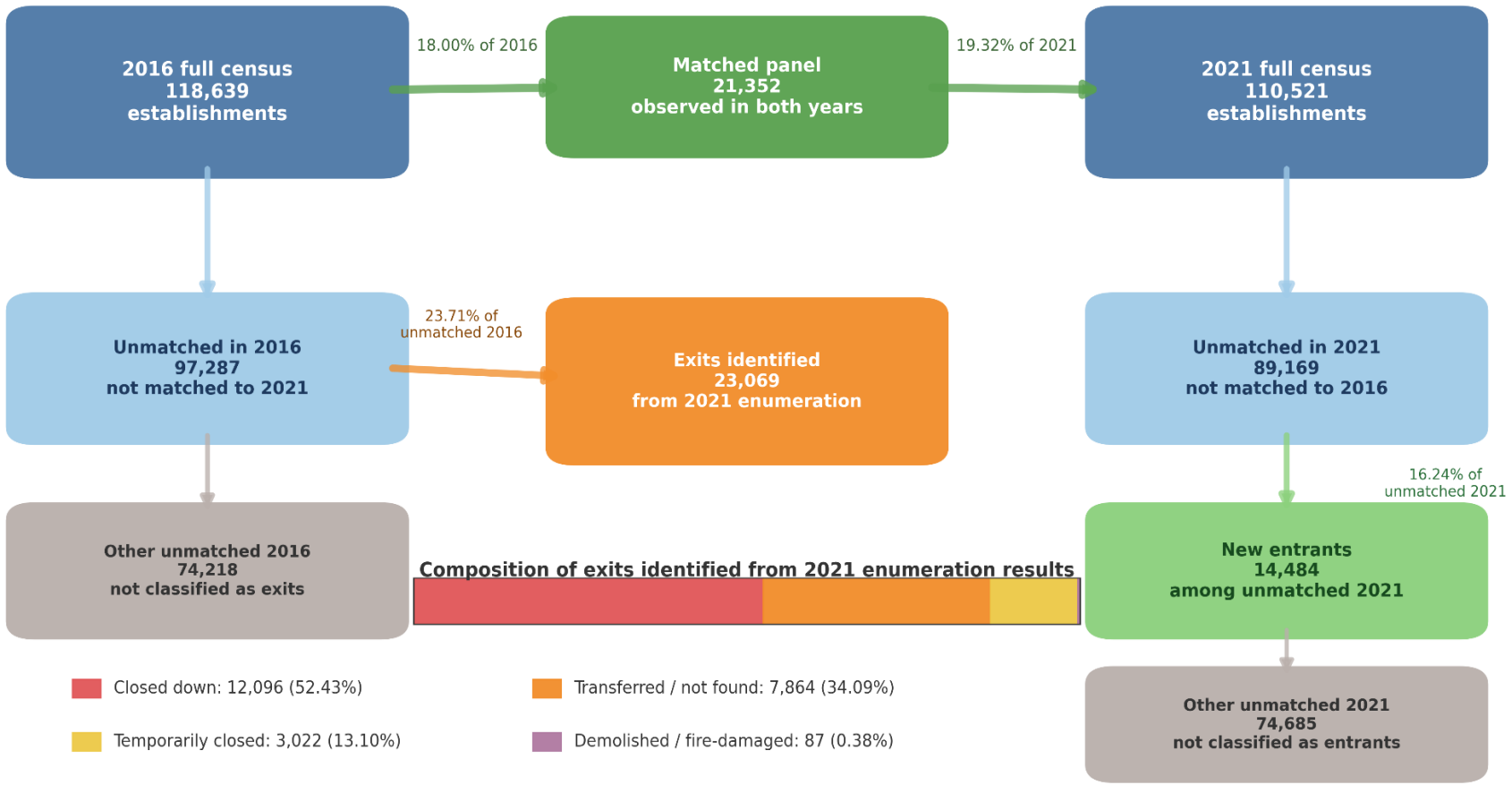
Total Factor Productivity
Labor Productivity
Cost Discipline

DATA INFRASTRUCTURE

Manufacturing sector from Thailand Industrial Censuses (2016-2021)

Establishment Dynamics between the 2016 and 2021 Industrial Census

Matched panel, unmatched establishments, exits, and new entrants



Usable exit cases in merged subset: 3,681 (15.96% of identified exits)

Note: Exit and entry information is based on 2021 enumeration results. Matched establishments are observed in both census rounds.

DESCRIPTIVE ANALYSIS

Manufacturing sector from Thailand Industrial Census (2016)

By foreign share holding	*Local 0%*	*(0, 10%)*	*>=10%*	*>=50%*	*100%*	*All*
No. of firms	20294	121	1058	555	261	21352
Share of sample	0.950	0.006	0.050	0.026	0.012	

BY GI certification	*No GI*	*GI lev. 1*	*GI lev. 2*	*GI lev. 3*	*GI lev. 4*	*GI lev. 5*	***All***
No. of firms	20225	400	300	348	39	40	21352
Share of sample	0.947	0.019	0.014	0.016	0.002	0.002	

427 *GI level 3 plus*

METHODOLOGY

Addressing Selection Bias & Simultaneity

1. Propensity Score Matching (PSM)

Controls for selection bias by matching FDI firms with comparable domestic peers based on 2016 baseline characteristics.

- Controls for firm characteristics including GI status, industry, province, age, size.
- Controls for baseline export orientation, BoI

2. Labor productivity, TFP, SFA technical efficiency, profit margins

Correct for simultaneity bias in input selection during productivity shocks.

- Uses intermediate inputs as proxy variables.
- Isolates true technological efficiency.

EMPIRICAL STRATEGY

Isolating Within-Firm Adjustment

$$\Delta Y_i = \alpha + \beta_1 FDI_i + \beta_2 GI_i + \beta_3 (FDI_i \times GI_i) + \gamma \Delta X_i + \Delta \varepsilon_i$$

Dependent Variable (ΔY)

Change in resilience outcomes (TFP, labor productivity, energy cost share) 2016–2021.

Interaction Term (β3)

Identifies the amplification effect of Green Industry alignment on FDI resilience.

Fixed Effects

First-difference framework absorbs all time-invariant firm heterogeneity.

Controls

Firm characteristics, **pre-shock exposure**: initial level of foreign shareholding, energy cost share, skill intensity, imported input share, skills, etc

FINDING from the baseline model 1

GI effects (each level) effects across FDI shareholding groups

During the 2016–2021 disruption window, majority foreign-owned firms exhibited vastly superior Total Factor Productivity (TFP) growth compared to domestic peers.

	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Local	FDI > 10%	FDI >= 50%	FDI 100%	Local	FDI >1 0%	FDI >= 50%	FDI 100%	Local	FDI >1 0%	FDI >= 50%	FDI 100%	Local	FDI > 10%	FDI >= 50%	FDI 100%
VARIABLES	**Labor Productivity**				**TFP**				**SFA**				**Profit Margin**			
GI level 1	-0.106	0.278	1.220**	0.969	0.814***	0.115	0.448**	0.631*	-0.0179	-0.0128	0.120*	0.0444	1.326	-5.463	-2.083	-10.22
	(0.181)	(0.294)	(0.487)	(0.721)	(0.221)	(0.274)	(0.206)	(0.344)	(0.0230)	(0.0378)	(0.0641)	(0.0974)	(2.503)	(4.268)	(7.379)	(11.31)
GI level 2	-0.216	0.191	0.642*	1.184*	-0.0556	-0.0262	0.151	0.105	-0.0447*	-0.00537	0.0583	0.120	-2.226	-2.137	-0.199	-1.462
	(0.194)	(0.273)	(0.383)	(0.614)	(0.237)	(0.255)	(0.162)	(0.293)	(0.0246)	(0.0351)	(0.0504)	(0.0829)	(2.682)	(3.971)	(5.796)	(9.633)
GI level 3	-0.204	0.153	0.0665	0.108	-0.0868	0.0871	0.233**	0.300**	-0.0380	0.0284	0.0266	0.0288	-0.121	4.227*	5.401	4.681
	(0.183)	(0.175)	(0.217)	(0.302)	(0.224)	(0.164)	(0.0918)	(0.144)	(0.0233)	(0.0225)	(0.0285)	(0.0408)	(2.538)	(2.544)	(3.281)	(4.740)
GI level 4	1.037*	0.100	0.00496	-1.330	0.766	-0.169	-0.0945	-0.0253	0.0774	-0.0519	-0.0350	-0.0321	2.133	1.787	-5.131	11.58
	(0.571)	(0.575)	(0.746)	(1.588)	(0.698)	(0.537)	(0.316)	(0.758)	(0.0726)	(0.0739)	(0.0981)	(0.214)	(7.902)	(8.350)	(11.29)	(24.90)
GI level 5	-0.346	0.129	0.239		-0.144	0.565	0.903**		-0.0311	0.00533	0.0412		6.007	11.35	15.66	
	(0.501)	(0.769)	(0.832)		(0.613)	(0.718)	(0.352)		(0.0637)	(0.0988)	(0.110)		(6.935)	(11.17)	(12.60)	
Constant	0.0346	0.0372	0.0718	-0.142	-0.0205	0.107	0.00654	0.0167	0.0122**	0.00676	0.00203	-0.0189	-5.638***	-5.218***	-4.730***	-4.464**
	(0.0387)	(0.0705)	(0.100)	(0.141)	(0.0473)	(0.0658)	(0.0425)	(0.0672)	(0.00492)	(0.00906)	(0.0132)	(0.0190)	(0.536)	(1.024)	(1.520)	(2.210)

FINDING from the baseline model 2

10% FDI shares increase LP &TFP by 0.1%

GI level 3+ across FDI shareholding groups

Effects become more pronounced at GI Level 3+, where systematic management and structural integration are more fully embedded.

Effects of GI3+ on each outcome	(1) Local	(2) FDI > 10%	(3) FDI >= 50%	(4) FDI 100%
on D.labour productivity	-0.106	0.122	-0.0196	-0.0269
	(0.166)	(0.165)	(0.206)	(0.299)
on D. TFP	-0.0578	0.0833	0.218**	0.263*
	(0.203)	(0.154)	(0.0874)	(0.141)
D.SFA	-0.026	0.023	0.015	0.0194
	(0.0211)	(0.0212)	(0.0270)	(0.0399)
D.profit margins	0.729	4.763**	5.357*	5.317
	(2.296)	(2.397)	(3.090)	(4.614)

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

FINDING from extended model with full controls for firm characteristics and pre-shock exposure variables

Resilience Premium by Ownership

Performance Resilience Outcome	FDI >50%	FDI <50%	Interpretation
Labor Productivity Growth	GI4: -0.664**	GI1: -0.189**; GI3: -0.147*; GI5: -0.324*	Negative effects concentrated among firms with low foreign ownership
TFP Growth	GI1: +0.306**; GI5: +0.529**	No significant effect	Productivity gains emerge only under majority foreign control
Technical Efficiency Growth	GI4: -0.098*	GI1: -0.027**; GI2: -0.046***; GI3: -0.037**	Efficiency losses are more pronounced among low-FDI firms
Profit Margin Change	GI1: +37.5*	No significant effect	Limited evidence that GI improves profitability

*Note: FDI baseline alone does not significantly reduce energy cost vulnerability. Institutional alignment is required.

Factor	FDI >50%	FDI <50%	Implication
Skill Share	Labor Prod.: +0.249*; TFP: +0.083*; TE: +0.049**	Labor Prod.: -0.085***; others insignificant	Skills generate returns only when supported by strong managerial capacity
Energy Cost Share (2016)	LP: -0.052***; TFP: -0.038***; TE: -0.012***	LP: -0.021***; TFP: -0.025***; TE: -0.006***	High initial energy dependence reduces productivity growth
Logistics Cost Share (2016)	LP: -0.036***; TFP: -0.015***; TE: -0.008***	LP: -0.024***; TFP: -0.018***; TE: -0.006***	Supply-chain costs constrain firm upgrading
GI × FDI Share	LP: +0.006** TFP: +0.002** TE: +0.001***		Foreign ownership strengthens the effectiveness of GI certification

FDI baseline alone does not significantly reduce cost vulnerability. Institutional alignment is required

FINDING 02

The Institutional Amplifier

GI Levels 1 & 2

Basic commitment and initial activities yield negligible resilience effects. Energy cost discipline remains weak under price shocks.

GI Level 3+

Systematic environmental management heavily amplifies FDI resilience. Firms successfully absorb energy-cost pressures without severe margin deterioration.

FINDING 03

Human Capital Complementarity

Productivity returns to green certification depend critically on skilled workforce capacity.

Technological and managerial upgrading required by GI compliance cannot be absorbed by low-skill operational structures.



Skill Intensity

LIMITATIONS

Identified Research constraints and next steps

Censored Shock Window

2021 census data captures pandemic disruption but misses the peak 2022 global energy price shock.

Unobserved Timing

Exact adoption dates for Green Industry certification tiers within the 5-year window are not tracked, as well as the progress in 2021.

Microenterprise Exclusion

Capital-driven dualism limits observation of micro enterprises with fewer than 11 employees, who face barriers to reaching any GI Levels.

Next steps on identification for FDI effects (more instrumental variables), cost-share as outcome variable and robustness check and Skill Threshold Matrix (for FDI Firms)

ACTIONABLE INSIGHTS

Policy Recommendations

01. Condition Incentives

Tie FDI attraction and BOI tax incentives directly to progression in Green Industry tiers (Level 3 minimum).

02. Target SME Barriers

Provide targeted capital and technical assistance to move domestic suppliers past Level 2 stagnation.

03. Upgrade Workforce

Align green industrial policy with skilled-labor technical development to realize full productivity spillovers.

Investment Needs Institutions.

High energy and logistics cost shares remain major barriers to firm performance, especially during the pandemic and the onset of the global energy crisis.

GI certification alone often imposes short-run adjustment costs. However, when combined with majority foreign ownership (>50%) and a skilled workforce, it enhances TFP and productivity growth.

FDI attraction is not enough. Robust green institutional frameworks and skill capabilities are required to build durable and sustainable supply chain resilience.

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Thank you for your attention!

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