Technological Innovation and the Spillover Effects of China's Energy Demand on Belt and Road Economies

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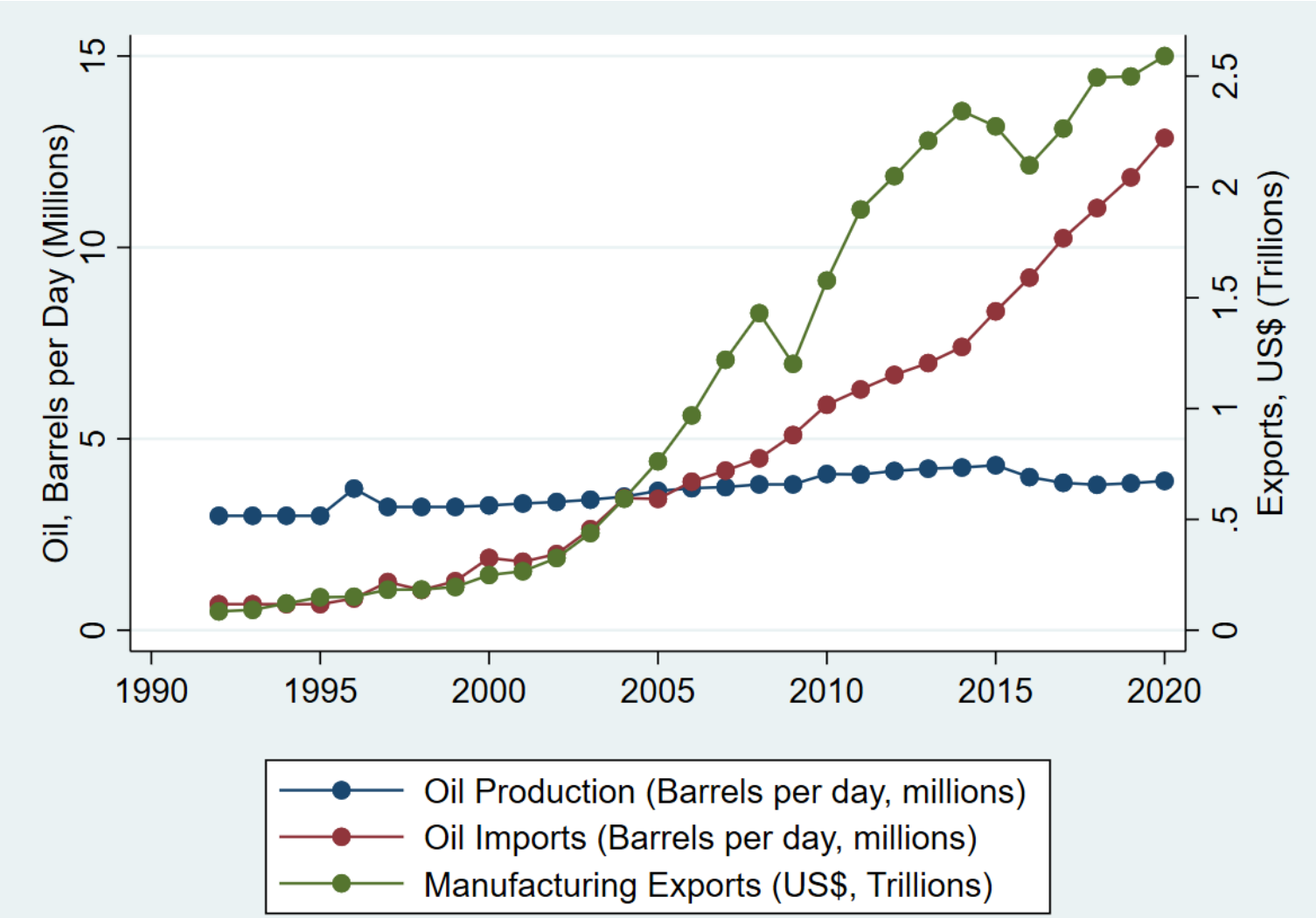
China's Energy Demand

- Energy is an important input factor for firms and its cost has risen tremendously over the past two decades.



Motivation

- ***Induced Innovation Hypothesis*** – changes in relative factor prices should lead to innovations that reduce the need for the relatively expensive factor (see [Newell, 2010]; [Wurlod and Noailly, 2018]; [Triguero et al., 2014]).

- Limited knowledge about the spillover effects of rising energy demand on innovation in developing countries (generally) and innovation not directly related to energy usage specifically (our focus).

Our Contribution

We aim to fill two gaps in the literature:

1. We model theoretically how the rise in China's global energy demand and its growing influence in developing economies' energy extraction and imports can affect firm-level innovation (similar approach to the agglomeration literature, see [Glaeser and Gottlieb, 2009] and [Duranton and Puga, 2004]) and the energy economics literature on proximity to oil production and knowledge spillover [Badeeb et al., 2016], [Fang and Chen, 2017], [Lim and Morris, 2022].

2. Empirically, we focus on product and process innovation and not patent counts, the main measure of innovation in the literature.

- Developing country focus.

Theoretical Setting

- The central question is whether China is crowding out innovation in the rest of the developing world?

- We differentiate the impact of China's energy demand on small energy exporting and energy importing economies.

Proposition 1: In a small oil exporting economy – the effect of the share of oil exported to China on a domestic firm's innovation engagement depends on the size of the efficiency gains it can make to offset the costs of substituting the source of its energy input.

Proposition 2: In a small oil importing economy – the effect of an increase in China's global energy demand on a domestic firm's innovation depends on the the difference between the magnitude of the competition effect and the energy efficiency effect.

Empirical Strategy – Proposition 1

We use data from 29 oil exporting countries to estimate:

$$Innovation_{ijct} = \alpha_0 + \alpha_1 EnergyExports_{(c-ch)t} + \alpha_2 Controls_{ijct} + \varepsilon_{ijct} \quad (1)$$

Where:

- $Innovation_{ijct}$ is the reported innovation of firm *i* in industry *j* of country *c* at time *t*
- *EnergyExports* is the domestic energy exported to China weighted by firm *i's* relative energy usage intensity.
- *Controls* is a battery of firm-characteristic variables, and dummies that capture region - year- income - (industry) - [country] specific fixed effects
- ε_{ijct} is the random error term with the usual properties

Empirical Strategy – Proposition 2

We use data from 61 countries with no oil exports to China:

$$Innovation_{ijct} = \beta_0 + \beta_1 EDP_{ijct} + \beta_2 Controls_{ijct} + \varepsilon_{ijct} \tag{2}$$

We need to compute a measure of the relative shock experienced by firm i in country c with increased oil demand in China.

$$\Delta EDP_i = \sum_i^N \frac{EI_i}{EI_j} \frac{\Delta M^c}{\Delta M^{Ch\_W}} \tag{3}$$

- EDP_i is the relative energy demand pressure
- ΔM^c is the change in imports of energy in country c
- ΔM^{Ch_W} is the change in oil imports in China from the rest of the world, using 1992 as the base year.
- EI is the relative energy intensity measured as the total cost of energy faced by a firm relative to its industry size.

Identification

There are at least two endogeneity concerns:

- Combined measurement and omitted variables issue – bilateral relationships may dictate China's energy policy.
- Simultaneity issue because energy exports may impact innovation but innovation (especially in the energy sector) may drive energy exports.

Solution:

1. Use an IV approach that builds on the gravity model idea and instrument *EnergyExports* and *EDP* with the bilateral distance between China and firm *i*.

Data

- Firm level data from the World Bank Enterprise Survey (WBES)
- 90 countries that have signed a Memorandum of Understanding (MoU) with China as part of the Belt and Road Initiative (BRI).
- We combine WBES data with energy data from the United Nations Commodity Trade Statistics Database (UN Comtrade).
- Bilateral distance data from [Mayer and Zignago, 2011].

Descriptive Statistics on Key Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Process	36,314	0.29	0.45	0	1
Product	36,314	0.25	0.44	0	1
Δ Energy Exports	11,726	0.24	1.84	-0.99	62.23
ΔEDP_{Ch-W}	25,006	2.65	3.66	-16.66	14.82
ΔEDP_{Ch-R}	25,006	3.82	3.70	-17.94	13.72

Results – Proposition 1

OLS with Energy Exports and Innovation

	(1) Process	(2) Product	(3) Process	(4) Product	(5) Process	(6) Product
ΔEE	0.025***	0.027***	0.001	0.006**	-0.001	0.009***
	(0.006)	(0.006)	(0.003)	(0.002)	(0.003)	(0.003)
Controls	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓
Reg FE			✓	✓	✓	✓
Inc FE					✓	✓
N	11726	11726	11726	11726	11726	11726

Results – Proposition 1

IV with Energy Exports and Innovation

	(1) Process	(2) Product	(3) Process	(4) Product	(5) Process	(6) Product
ΔEE	0.225***	0.256***	0.230***	0.256***	0.229***	0.256***
	(0.042)	(0.010)	(0.042)	(0.010)	(0.042)	(0.010)
F Stage F	18.314	22.531	22.516	21.236	12.286	23.800
Controls	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓
Reg FE	✓	✓	✓	✓	✓	✓
Inc FE	✓	✓	✓	✓	✓	✓
N	8339	8339	8339	8339	8339	8339

Results – Proposition 2

IV with Energy Demand Pressure and Innovation

	(1) Process	(2) Product	(3) Process	(4) Product	(5) Process	(6) Product
ΔEDP	0.052***	0.113***	0.051***	0.112***	0.051***	0.111***
	(0.007)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)
F Stage F	15.314	281.531	26.516	259.236	10.286	93.833
Controls	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓
Reg FE	✓	✓	✓	✓	✓	✓
Inc FE	✓	✓	✓	✓	✓	✓
N	25006	25006	25006	25006	25006	25006

Summary

- We model theoretically how the rise in China's global energy demand influences innovation in other developing countries.
- We focus on countries that are part of China's Belt and Road Initiative (BRI).
- We use an instrumental variables strategy and show there is a positive and robust positive impact of China's increased energy demand on innovation in BRI countries.

Thank You!

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