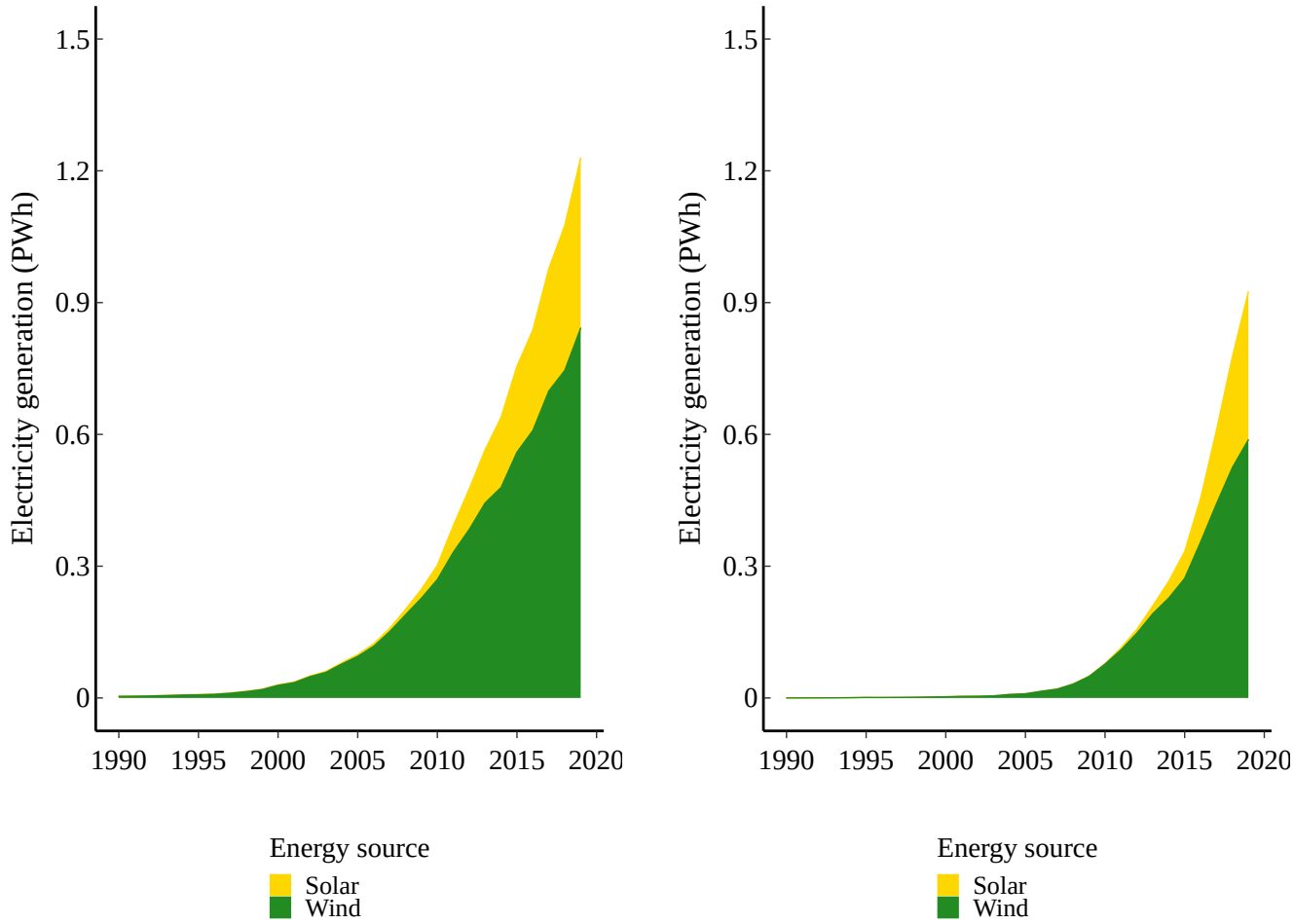
Holding Up Green Energy

Nicholas Ryan (Yale)

NBER DEV Summer Institute
June 26th, 2021

Green energy production is soaring

Figure: Electricity generation from solar and wind

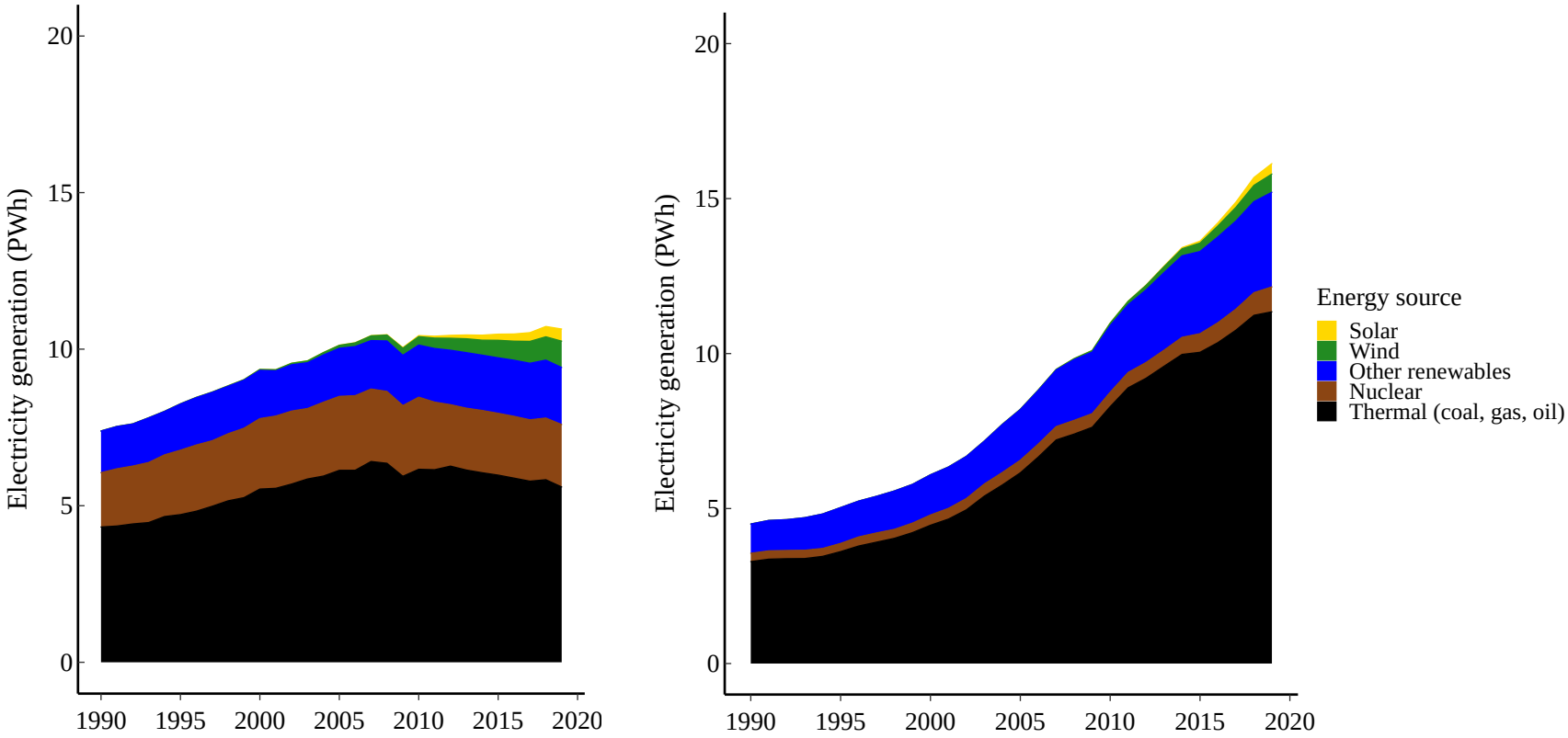


A. OECD countries

B. Non-OECD countries

. . . but there is a long way to go

Figure: Electricity generation by source



A. OECD countries

B. Non-OECD countries

- Renewables investment of $131 trillion needed to meet UN's aggressive climate goals (IRENA, 2021)

Counterparty risk may hinder investment

South Africa Open Again for Renewables After Auction Turmoil

But will developers be interested after the recent problems with the market?

JASON DEIGN | JULY 05, 2018

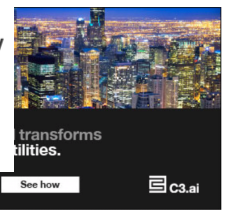


2

"While the rand has mostly rebounded from its 2015-2016 slump, the biggest barrier to bid Window 5's success will likely be embattled state utility Eskom, which has faced a host of cashflow issues



South Africa tries to get its renewable energy industry back on track.



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Industry Stunned as Mexico Cancels Clean Power Auction

A new president looks to hand the market back to state-owned entities.



JASON DEIGN | FEBRUARY 04, 2019



7

the shock created by the auction cancellation is likely to have spooked investors that were previously bullish on Mexican renewables. "The mood can sour very quickly in a developing market,"



President López Obrador accused the previous government of scaremongering over blackouts.

E*TRADE Open an account
E*TRADE Securities, LLC

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South Africa t

Turkey scraps 1 GW solar tender

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JANUARY 14, 2019 EMILIANO BELLINI

MODULES & UPSTREAM MANUFACTURING | POLICY | UTILITY SCALE PV | UTILITY SCALE STORAGE | TURKEY





Ankara said the solar tender will be rerun later in the year.

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UTILITIES - ELECTRIC JUNE 13, 2016 / 3:15 PM / UPDATED 5 YEARS AGO

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Ankara said the solar tender will be rerun later in

World Bank's Zambia solar auction sets African low price benchmark

By David Lawder 3 MIN READ

The World Bank program aims to help governments deliver cheap and clean energy by helping them run competitive auctions and reducing investment risks. It includes a full suite of World Bank products and services, including IFC financing and advice as well as guarantees from the group's Multilateral Investment Guarantee Agency arm.

Does hold-up hurt investment in green energy?

- Developing countries are at a disadvantage in relationship-specific investments due to weak contract enforcement (Nunn, 2007)
- Many investments in energy are relationship-specific (Klein, Crawford and Alchian, 1978; Joskow, 1987, 1988)
- Green energy might be even more vulnerable to hold-up:
  1. **Bargaining power**. Since the marginal cost of production is low, buyers of power will have bargaining power *ex post*.
  2. **Technological change**. Green energy investment requires buyers to commit to contracts, in an environment when prices are always falling.
- **Research Questions:** Does hold up risk raise green energy prices? Reduce investment?

Empirical approach

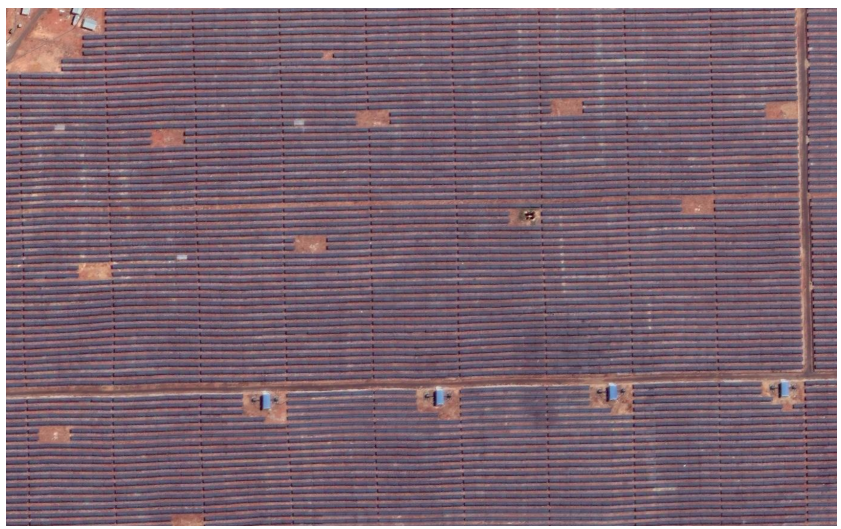
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- Approach: use **counterparty risk** $\times$ **intermediation**
  - **State buyers.** States buy power to sell to customers.
  - **Counterparty risk.** These states are unreliable buyers.
  - **Intermediation.** In some auctions, the central government "buys" power and resells to states, protecting solar firms from non-payment.

Figure: Solar power plants in Anantapur district, Andhra Pradesh



A. Central auction



B. State auction

Empirical approach

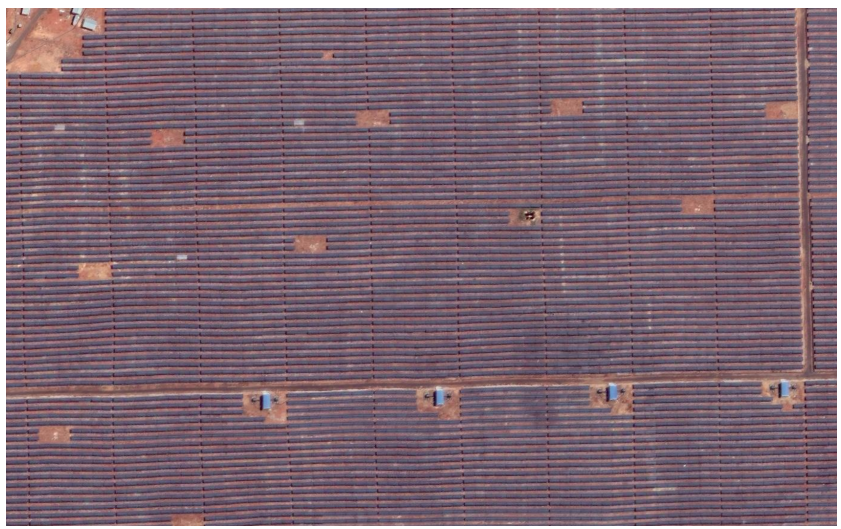
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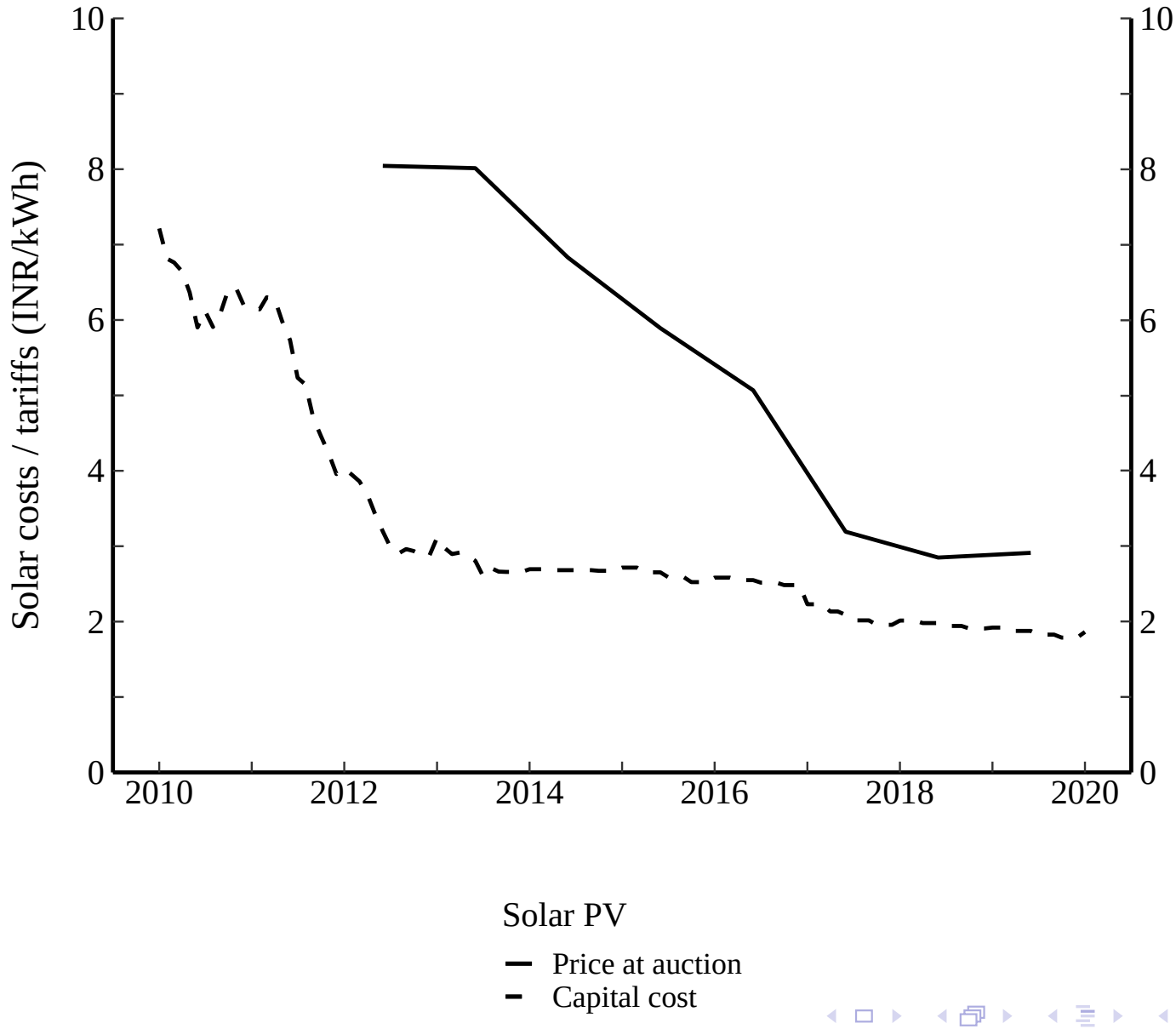
Solar costs and prices have plummeted

Figure: Solar costs and prices



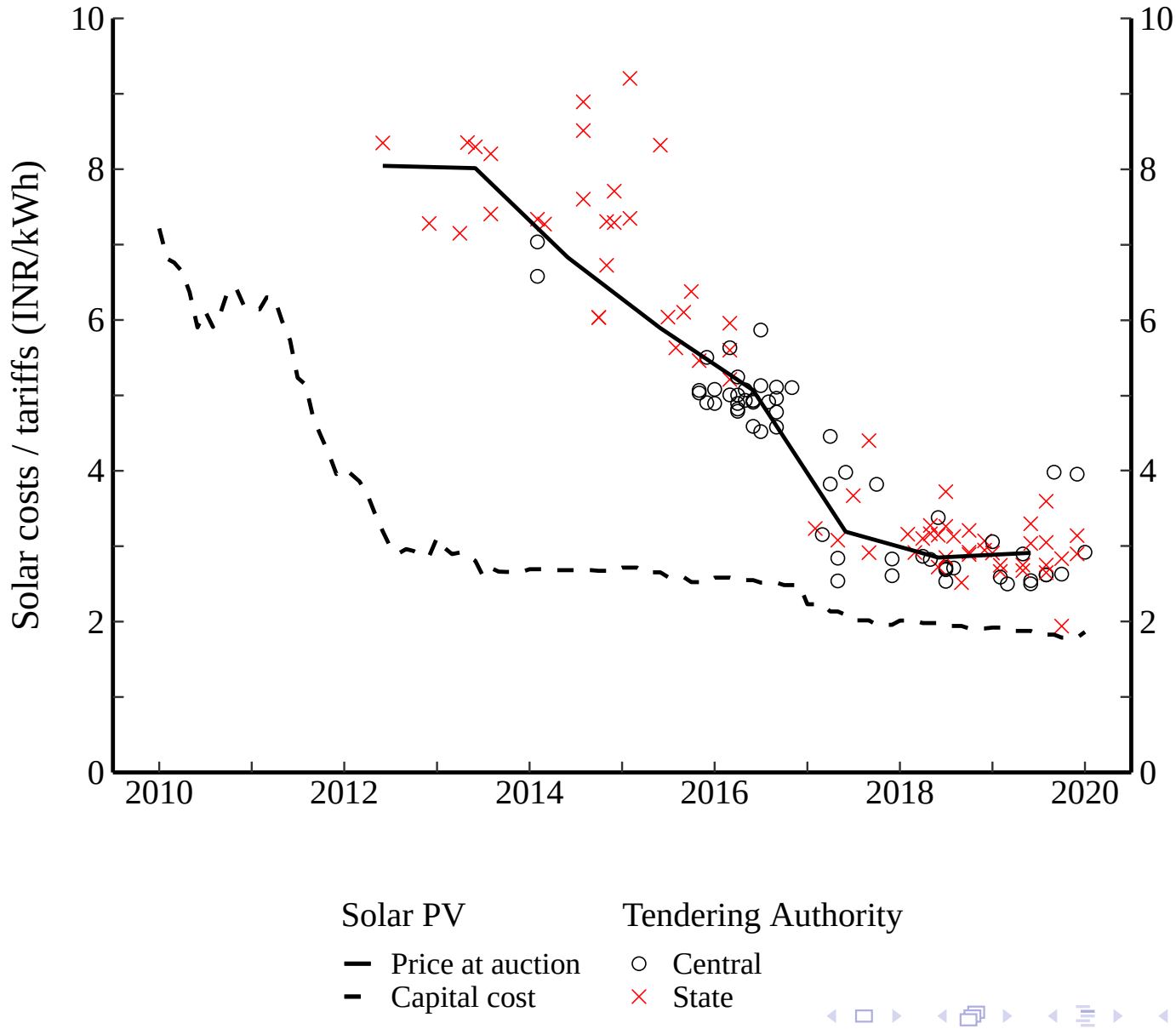
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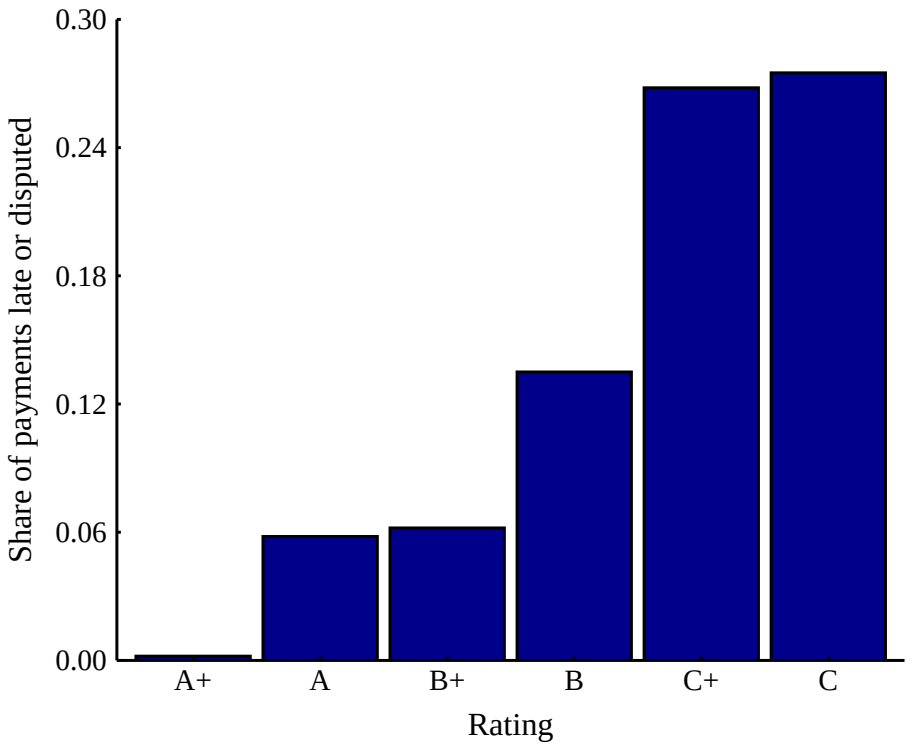
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Specification: Auction bids by state risk

Figure: Counterparty risk for Indian electricity distribution companies



Measure risk. Let $GPA_s \in [0, 4.3]$ be the GPA of the state's letter grade from the Ministry of Power. Counterparty risk measure is:

$$CounterpartyRisk_s = \frac{4.3 - GPA_s}{4.3 - \overline{GPA_s}}.$$

Normalized:

$$\begin{aligned} 0 &= \text{no risk (A+ rating)} \\ 1 &= \text{average risk state (B+ rating).} \end{aligned}$$

Specification: Auction bids by state risk

Bid price regression.

$$\begin{aligned}\log b_{iat} \quad = \quad & Central_{at}\beta_1 + Irradiance_s\beta_2 \\ & + CounterpartyRisk_s\beta_3 \\ & + State_{at} \times CounterpartyRisk_s\beta_4 \\ & + \delta_t + \gamma_i + f(q_{at}) + \epsilon_{iat}.\end{aligned}$$

β_3 measures the effect of risk in central (intermediated) auctions.
β_4 measures the effect of risk in state auctions.
γ_i Bidder fixed effects (in some specifications).

Central intermediation lowers prices

	Dependent variable: Log of bid price (INR/kWh)			
	(1)	(2)	(3)	(4)
Central auction (=1)	−0.060***	−0.058**	0.035	0.010
	(0.022)	(0.023)	(0.036)	(0.034)
Solar irradiance	−0.29***	−0.28***	−0.19***	−0.16***
	(0.050)	(0.050)	(0.049)	(0.045)
Counterparty risk		0.014	−0.048**	−0.040
		(0.021)	(0.023)	(0.024)
State auction ×			0.15***	0.11***
Counterparty risk			(0.042)	(0.038)
Year effects	*Yes*	*Yes*	*Yes*	*Yes*
Capacity deciles	*Yes*	*Yes*	*Yes*	*Yes*
Firm effects				*Yes*
Mean dep. var	1.62	1.62	1.62	1.62
R^2	0.92	0.92	0.93	0.96
Auctions	124	124	124	124
Bids	1166	1166	1166	1166

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Risk does not increase prices overall

	Dependent variable: Log of bid price (INR/kWh)			
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RIsk differentially raise prices in state auctions

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The same firms bid higher when facing risk

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	(1)	(2)	(3)	(4)
Central auction (=1)	−0.060***	−0.058**	0.035	0.010
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Solar irradiance (W/m^2)	−0.29***	−0.28***	−0.19***	−0.16***
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Results up to now

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   - The risk premium in an average state is 10%.
   - Like moving a solar plant from Kentucky $\Rightarrow$ New Hampshire

2. **Intermediation eliminates counterparty risk**.
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3. **Does risk decrease investment**?
   - It depends on whether demand is elastic.
   - Many states set ceiling prices to try to hold bids down.

I estimate a model of bidding in solar auctions under varying risk levels to trace out the supply curves facing procurers of different risk

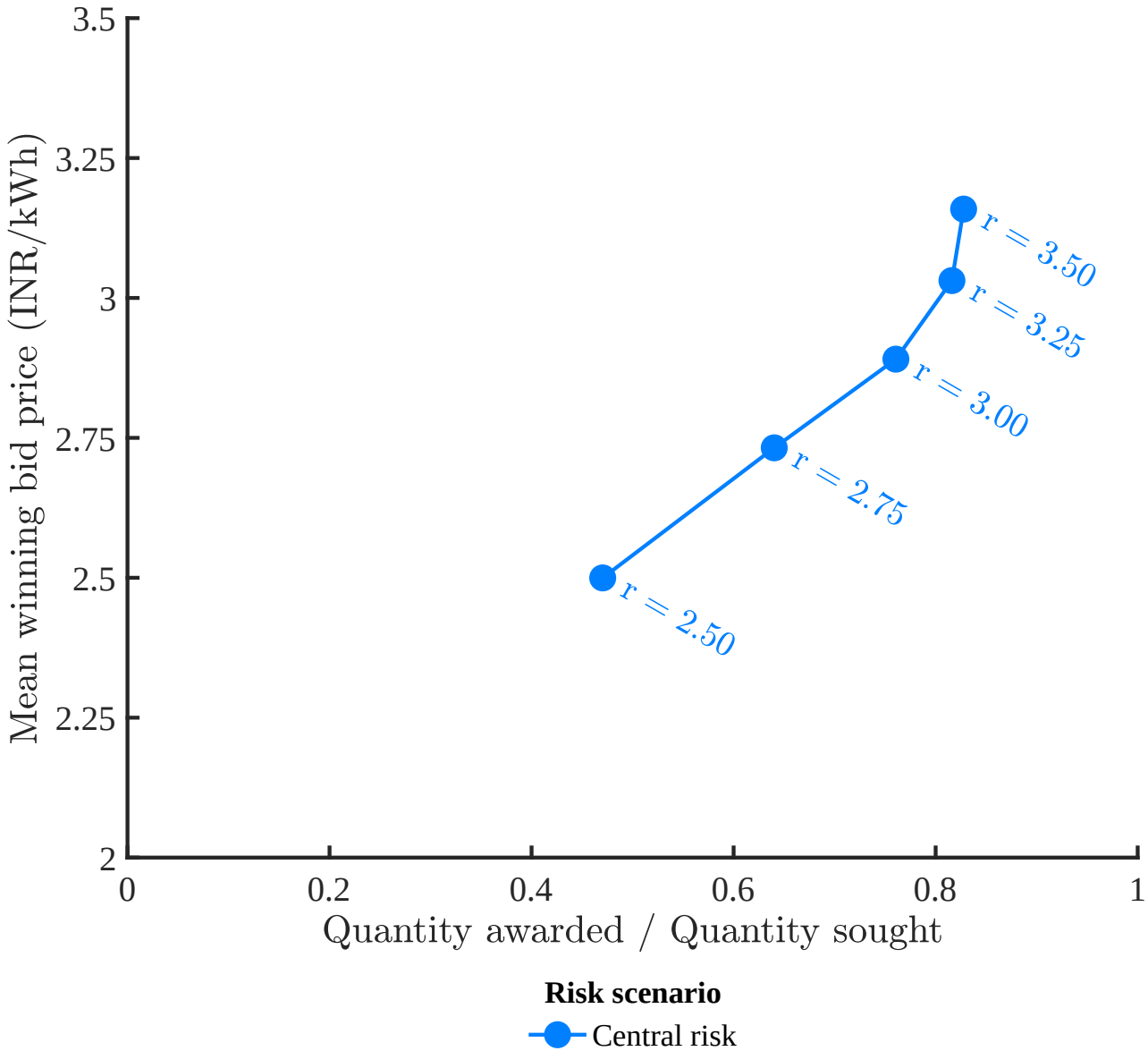
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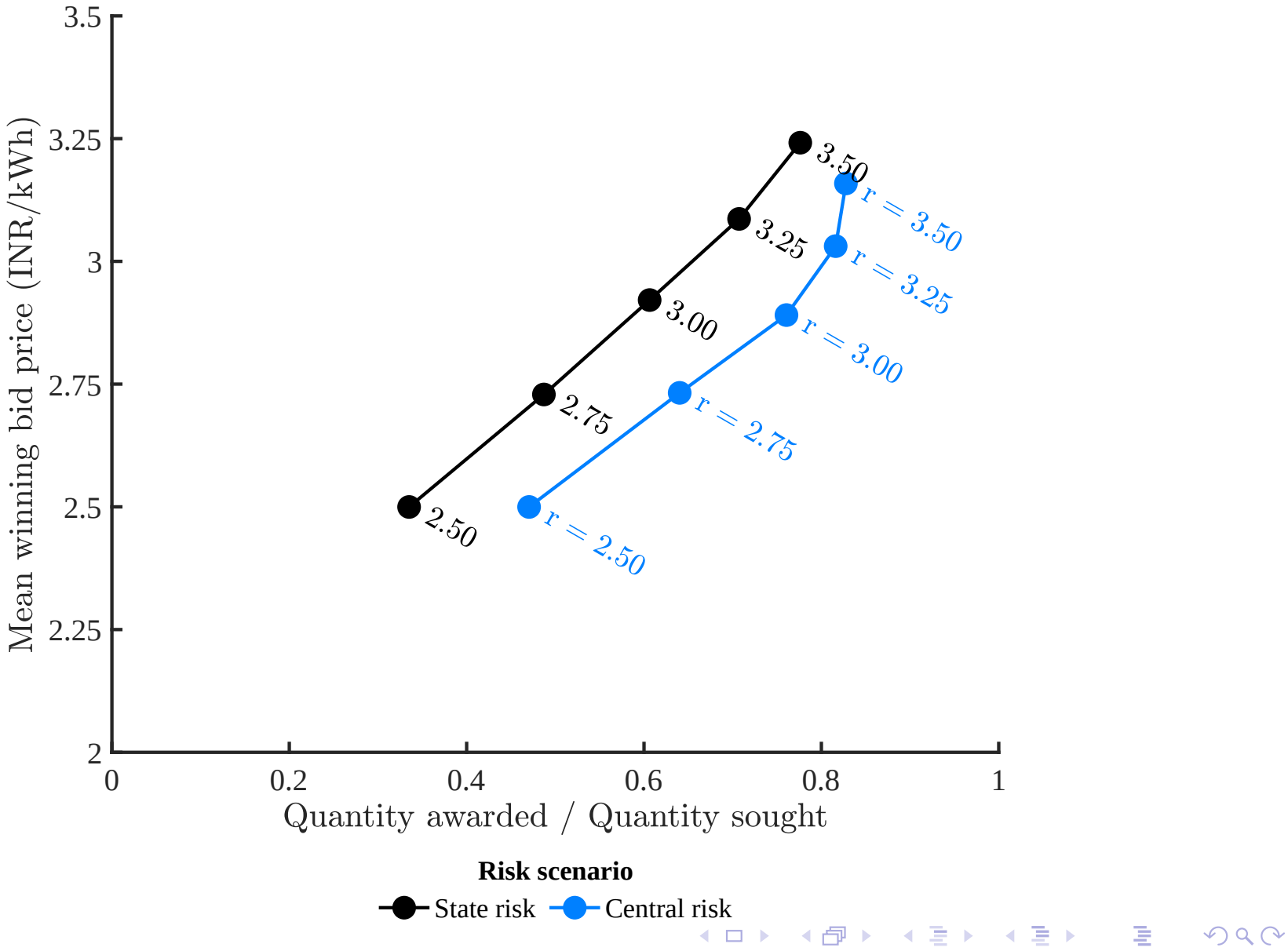
Counterparty risk reduces investment

Figure: Auction outcomes under varying risk levels



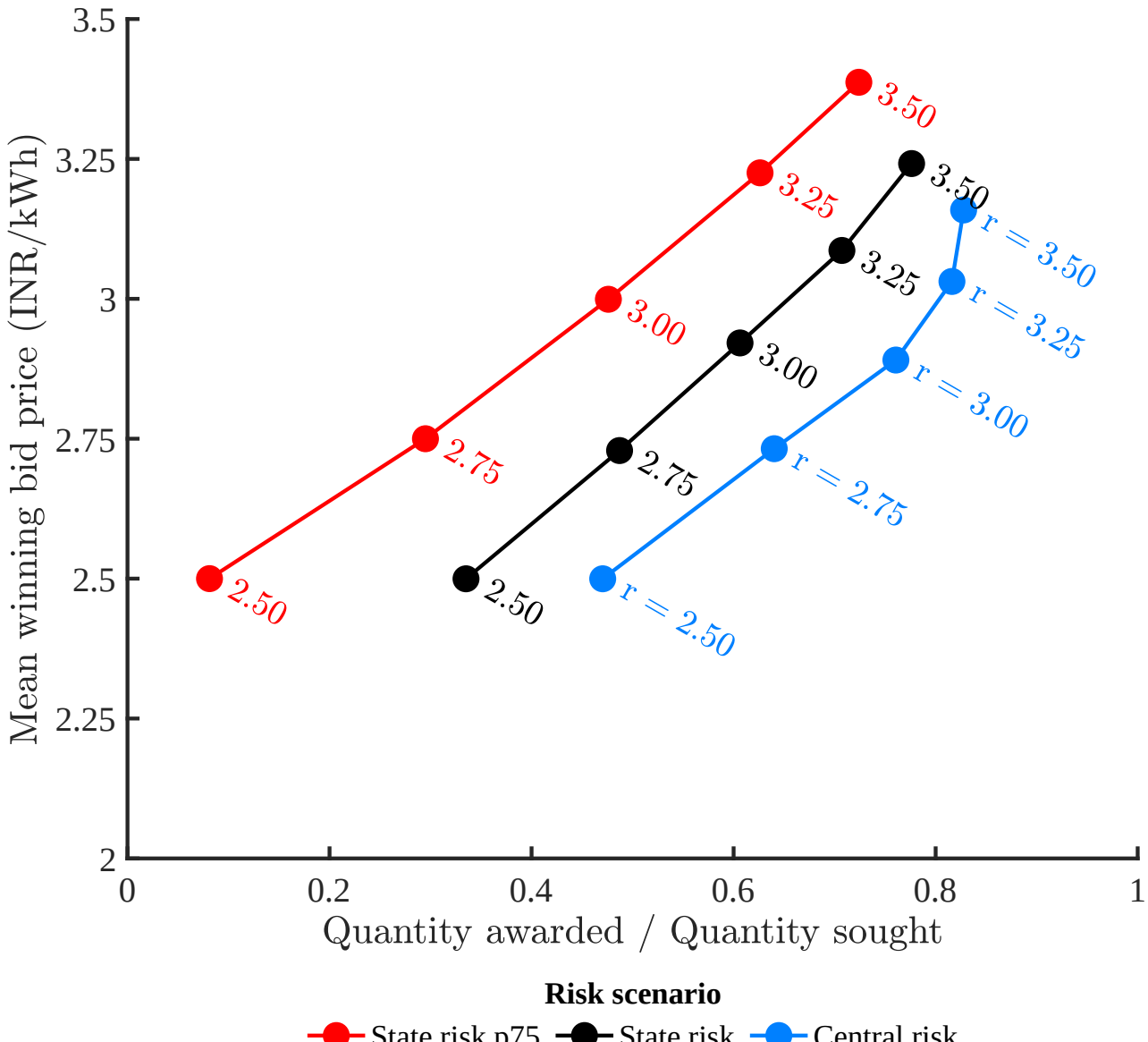
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Figure: Auction outcomes under varying risk levels



Counterparty risk reduces investment

Figure: Auction outcomes under varying risk levels



Counterparty risk reduces investment

1. **Policy actually adopted**. Actual ceiling prices reduce quantity procured by 16%

2. **Counterfactual risk effect**. At p75 state risk, the same ceiling prices reduce quantity by 35%



Figure: Ananthapuramu - II Mega Solar Park (400 MW)

The foregone quantity of investment under ceiling prices equals one of the above power plants for every four auctions run.

Conclusion

- *States reduce quantity procured in response to the counterparty risk that states themselves create.*

- Two features here are common to many developing countries:
  1. Counterparty risk
  2. Elastic demand

- Institutions for contract enforcement (e.g. World Bank's IFC) matter for the adoption of cheap green energy in developing countries.