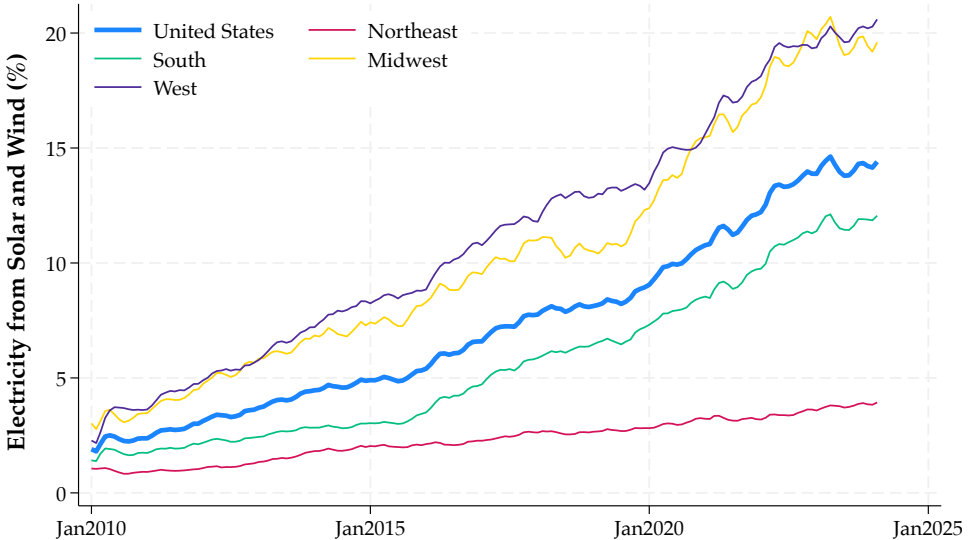
# The Economic Impacts of Clean Power

**Costas Arkolakis** Yale

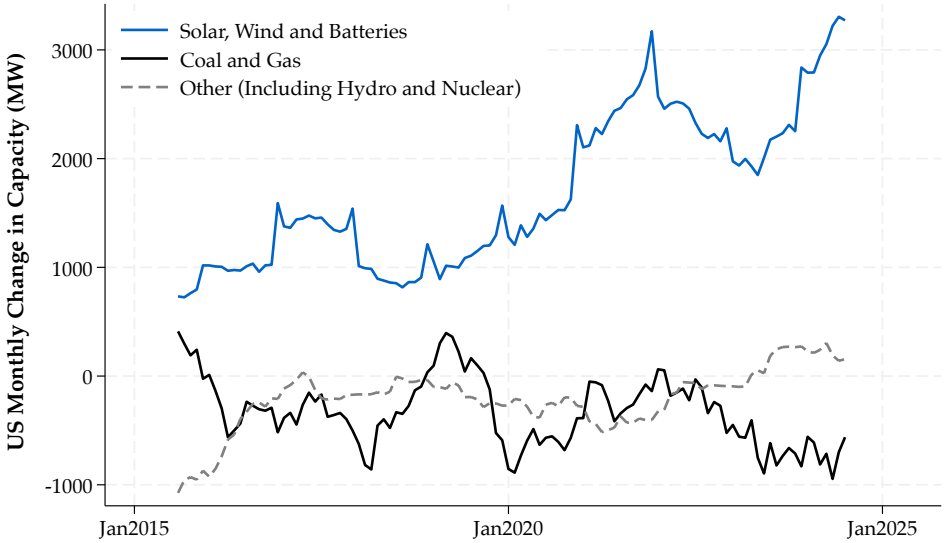
**Conor Walsh** Columbia

Brookings Papers on Economic Activity
September 2024

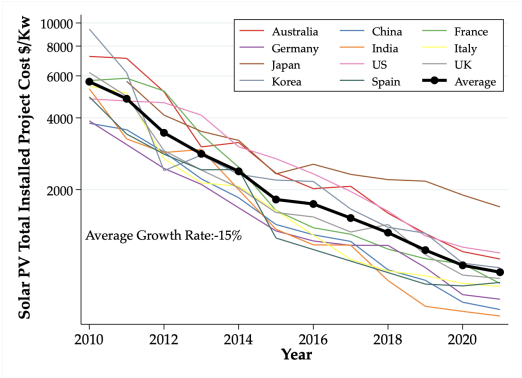
# Renewable energy has been increasing rapidly in the US



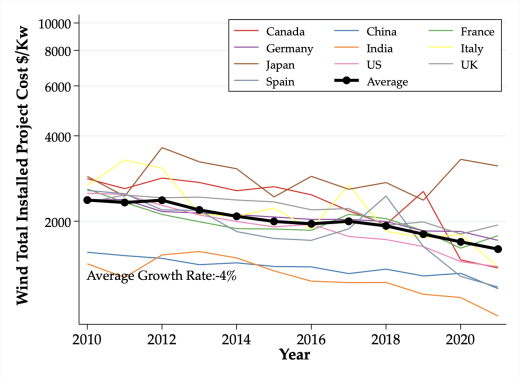
# Flows into new generation are now dominated by solar and wind



# Part of a worldwide shift driven by rapid cost declines




Solar Project Costs




Wind Project Costs

# We assess the economic impact of high renewable penetration

- Our paper has three parts. We:

# We assess the economic impact of high renewable penetration

- Our paper has three parts. We:

  1. Use **capital cost projections** to develop electricity ***price bounds*** at the local level

# We assess the economic impact of high renewable penetration

- Our paper has three parts. We:

  1. Use **capital cost projections** to develop electricity ***price bounds*** at the local level
  2. Use bounds in a class of **spatial general equilibrium models** to esimate impact on local **wages**

# We assess the economic impact of high renewable penetration

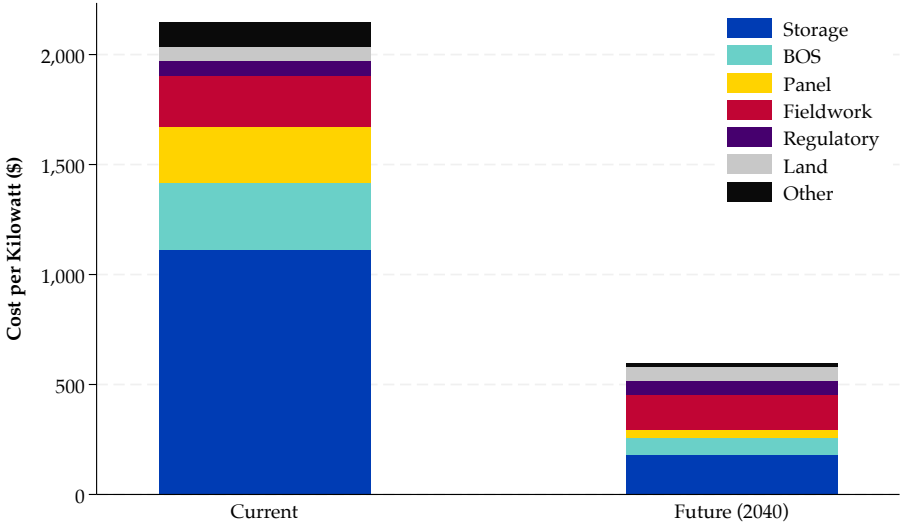
- Our paper has three parts. We:

1. Use **capital cost projections** to develop electricity ***price bounds*** at the local level
2. Use bounds in a class of **spatial general equilibrium models** to esimate impact on local **wages**
3. Use a long-term **growth model** to model how renewables shift **aggregate innovation**

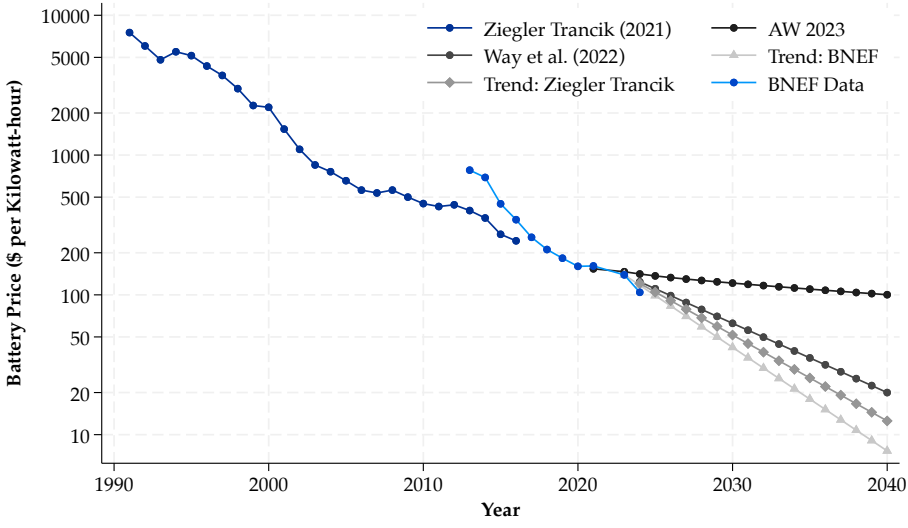
# We assess the economic impact of high renewable penetration

- Our paper has three parts. We:
  1. Use **capital cost projections** to develop electricity ***price bounds*** at the local level
  2. Use bounds in a class of **spatial general equilibrium models** to esimate impact on local **wages**
  3. Use a long-term **growth model** to model how renewables shift **aggregate innovation**
- Our purpose is to ask “What if”, and take technological trends seriously

# Projected costs of firmed solar fall significantly by 2040



# Batteries in particular have fallen in price, expected to get cheaper



# Use capital cost to develop local price bound

- In 2040, a project being installed at all in cost $Q_\ell$ expects average revenues to cover this cost:

$$Q_\ell = \sum_{t=1}^{T} R_{0\to t}^{-1} \theta_\ell p_{\ell t}^{\mathcal{E}} (1-\delta)^t$$

- Renewables have zero fuel cost, receive $\theta_\ell p_{\ell t}^{\mathcal{E}}$ in electricity revenue
- Potential output $\theta_\ell$ varies significantly across space
- Won't hold with equality everywhere (e.g. urban areas), so $p_{\ell t}^{\mathcal{E}}$ an **upper bound**

# Use capital cost to develop local price bound

- In 2040, a project being installed at all in cost $Q_\ell$ expects average revenues to cover this cost:

$$Q_\ell = \sum_{t=1}^{T} R_{0\to t}^{-1} \theta_\ell p_{\ell t}^{\mathcal{E}} (1-\delta)^t$$

- Renewables have zero fuel cost, receive $\theta_\ell p_{\ell t}^{\mathcal{E}}$ in electricity revenue
- Potential output $\theta_\ell$ varies significantly across space
- Won't hold with equality everywhere (e.g. urban areas), so $p_{\ell t}^{\mathcal{E}}$ an **upper bound**

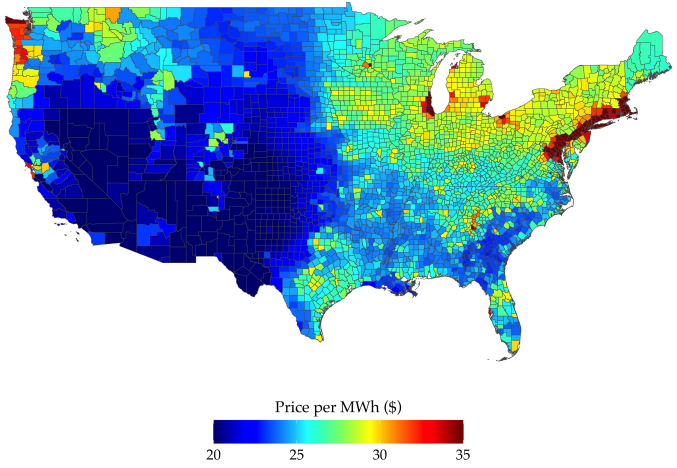
# Use capital cost to develop local price bound

- In 2040, a project being installed at all in cost $Q_\ell$ expects average revenues to cover this cost:

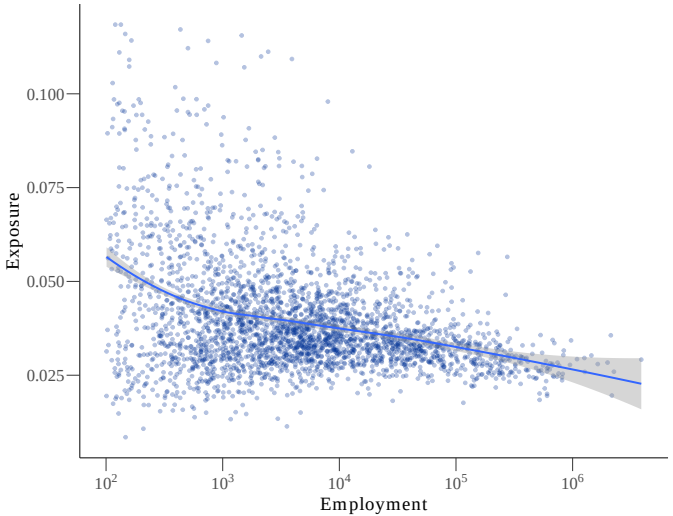
$$Q_\ell = \sum_{t=1}^{T} R_{0\to t}^{-1} \theta_\ell p_{\ell t}^{\mathcal{E}} (1-\delta)^t$$

- Renewables have zero fuel cost, receive $\theta_\ell p_{\ell t}^{\mathcal{E}}$ in electricity revenue
- Potential output $\theta_\ell$ varies significantly across space
- Won't hold with equality everywhere (e.g. urban areas), so $p_{\ell t}^{\mathcal{E}}$ an **upper bound**

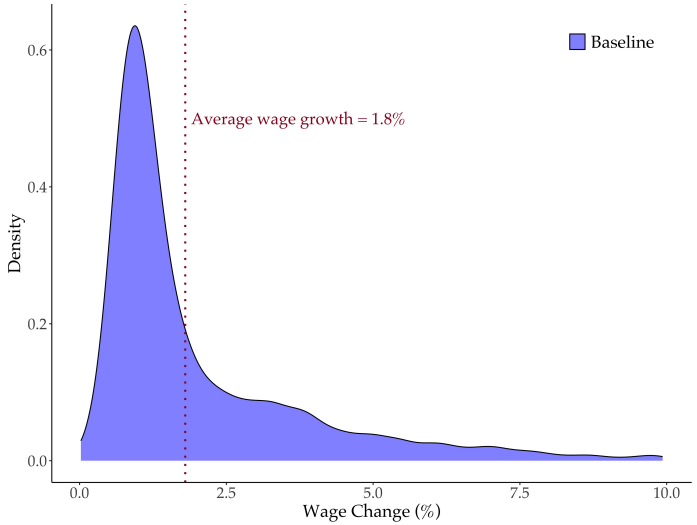
# Wholesale price bounds are low and spatially heterogeneous



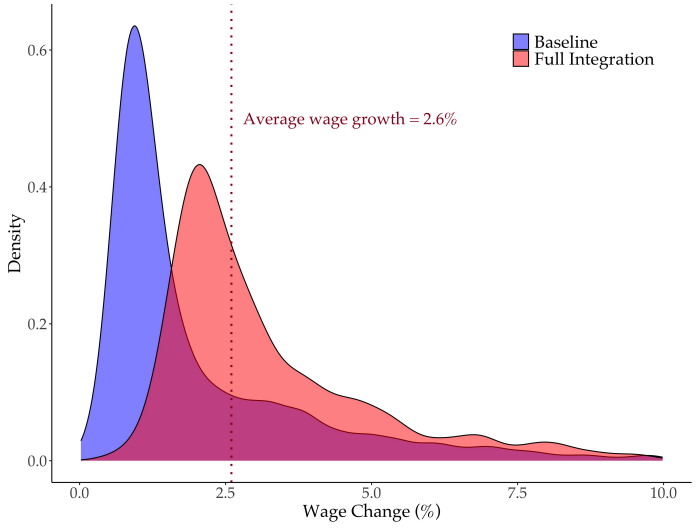
# Local wage responses vary depending on local industrial structure



# Local wage responses vary depending on local industrial structure

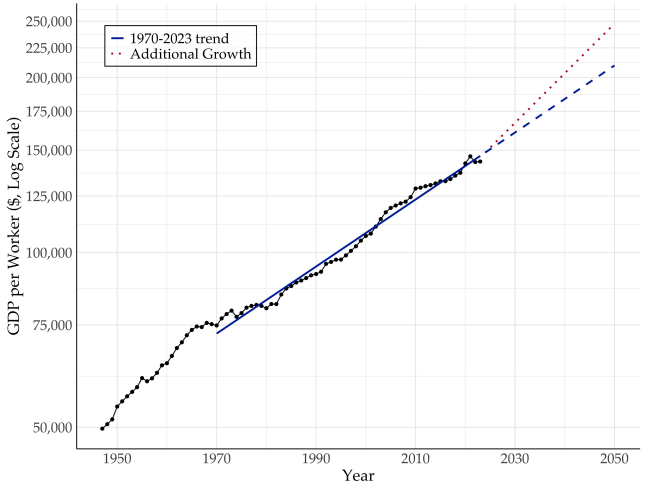


# Building out the grid could significantly raise the benefits

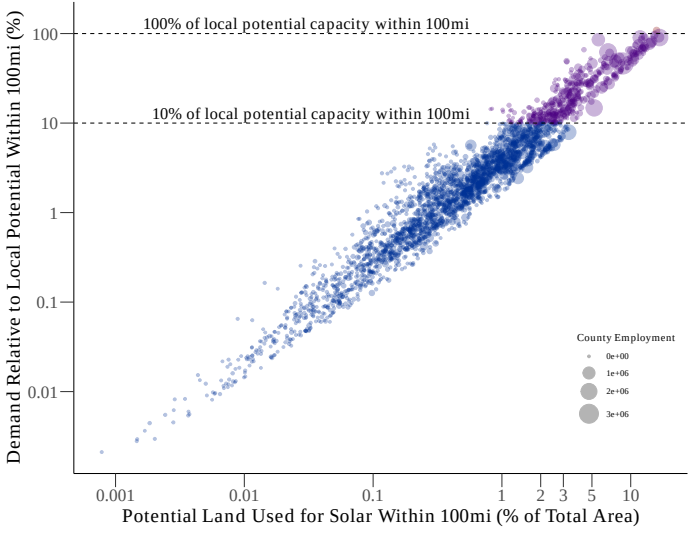


# Appendix

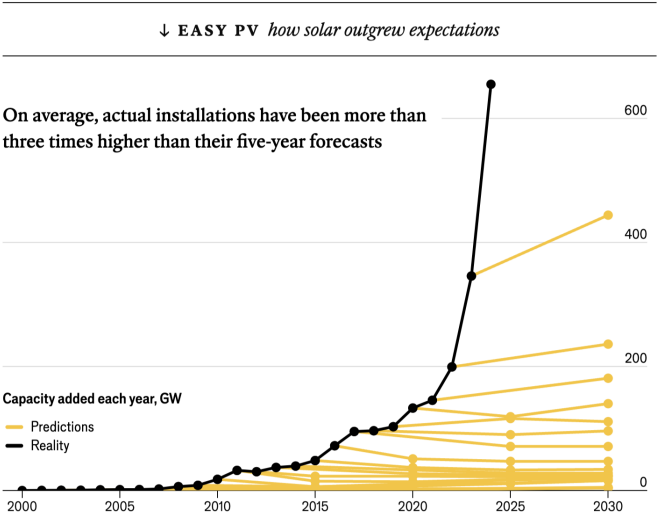
# Shifting to renewables could stop the ”resource drag” on growth



# Is unconstrained local entry a reasonable assumption?



# A long history of underestimation




Installations for 2024 are an estimate from BloombergNEF for direct current solar capacity

Sources: IEA; Energy Institute; BloombergNEF