Can Green Government Spending Facilitate Employment Transitions in a Low Carbon Economy?

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Introduction

- The effect of environmental policy on employment is still hotly debated
  - Environmental advocates argue that stronger environmental policies create high-paying "green jobs"
  - Critics point to expected job losses from environmental policy

- Recent political events show that politicians ignore the costs of environmental regulations on affected workers at their peril
  - Even if the net effect on employment is small, there may be particular workers whose skills are no longer demanded in a green economy

- Our research asks whether government spending designed to create new green jobs will be effective in regions where workers currently lack the skills needed for these jobs

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Introduction

- We identify green stimulus as part of the American Recovery and Reinvestment Act (ARRA) of 2009 in response to the Great Recession

- We estimate the effect of green stimulus spending on local green and non-green employment

- We test whether the effectiveness of such spending varies depending on the pre-recession composition of Green General Skills in the local workforce

- Preliminary findings suggest that while the average effect is not significant, green stimulus has larger long-term effects where green skills are initially more concentrated

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Literature Review

- Empirical evidence of environmental regulation's effect on employment is mixed
  - Many studies find limited evidence of job losses from environmental regulation (e.g. Berman and Bui *JPubEcon* 2001, Greenstone *JPE* 2002, Ferris *et al*. *JAERE* 2014)
  - Recent studies such as Kahn and Mansur (*JPubEcon* 2013) and Yamazaki (*JEEM* 2017) show that the employment effects of environmental regulation vary by industry
    - Suggests job losses in one sector often offset by gains in another

- Raises important questions about the distributional effects of any environmental regulation, such as new low-carbon policies

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Literature Review

- Yamazaki's (2017) study of B.C. carbon tax
  - Overall, industries benefit from redistributed tax revenues, so that aggregate employment increased after the tax
  - However, employment falls in industries:
    - with large carbon emissions intensities
    - more exposed to international trade
  - Largest percentage job losses in:
    - basic chemical manufacturing, petroleum and coal product manufacturing, and electric power generation, transmission and distribution
  - Largest percentage employment gains in:
    - health services, hospitals, and retail trades

- These are industries requiring very different skill sets!

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Literature Review

- Fiscal stimulus and job multipliers literature
  - Several papers estimate returns to overall stimulus on employment (Wilson (*AEJ-EP*, 2012; Feyrer and Sacerdote, 2011; Dupor and Mekhari (*EER*, 2016); Dupor and McCrory (*EJ*, 2018); Garin (2019 *J Urb Econ*)
    - Roughly $100,000 - $200,000 per job created
  - Vona *et al*. (*JOEG*, 2019): large (about 4) green job local multiplier for US metro and non-metro areas

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Green jobs and green skills

- A focus on skills informs how easy it may be for individuals losing jobs to find new employment in potentially very different sectors

- Vona et al. (*JAERE* 2018) identified Green Skills using data from the U.S. Department of Labor's O*NET database

- For each occupation, O*NET lists several tasks
  - Occupational specific (only for each occupation)
    - Further divided into *green* and *non-green* specific tasks
  - General Tasks
    - Possibly used in all occupations
    - Provides an importance score for these skills (1: low importance; 5: high importance)

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Green jobs and green skills

- Examples
  - Sheet metal workers
    - Green Tasks:
      - Constructing ducts for high efficiency heating systems or components for wind turbine
    - Non-green tasks:
      - Developing patterns using computerized metal working equipment
  - Electrical engineers
    - Green Tasks:
      - Design electrical components that minimize energy requirements
    - Non-green tasks:
      - Plan layout of electric power generating plants or distribution lines

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Green jobs and green skills

- Calculating *Green General Skills*
  1. Define greenness of an occupation based on number of specific green tasks required
     - Allows for more nuanced distinction of green jobs than O*NET (e.g. are sheet metal workers *fully* green?
  2. Use to identify general skills associated with greener occupations
     - To see the extent to which current workforce skills can be easily transferred to green activities

- *Green General Skills* are mainly in science and engineering, and are often associated with high-skilled labor

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Data

- We assemble a longitudinal dataset of local labor markets in the U.S. from 2005 to 2017
  - 684 commuting zones in 50 states and DC
  - Combine data on employment and labor market conditions with data on stimulus spending

Green Stimulus

- The US American Recovery and Reinvestment Act (ARRA) of 2009 invested over $800 billion stimulate the US economy
  - Included several programs designed to promote clean energy and green jobs (Aldy, 2013)
  - Using data from FedSpending.org, we identify as "green" stimulus spending ARRA spending from the Department of Energy and Environmental Protection Agency
    - Major categories: cleanup of polluted sites, energy efficiency retrofits, or the development of renewable energy resources
    - Approximately ten percent of projects from EPA and DOE pertain to research
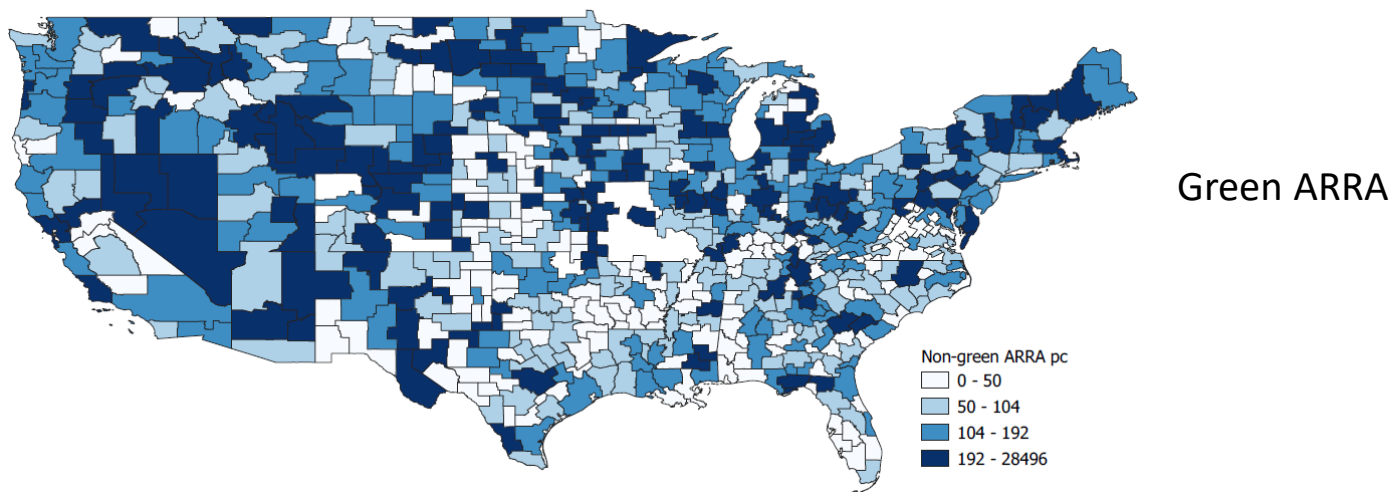   - One percent for job training

Allocation of ARRA

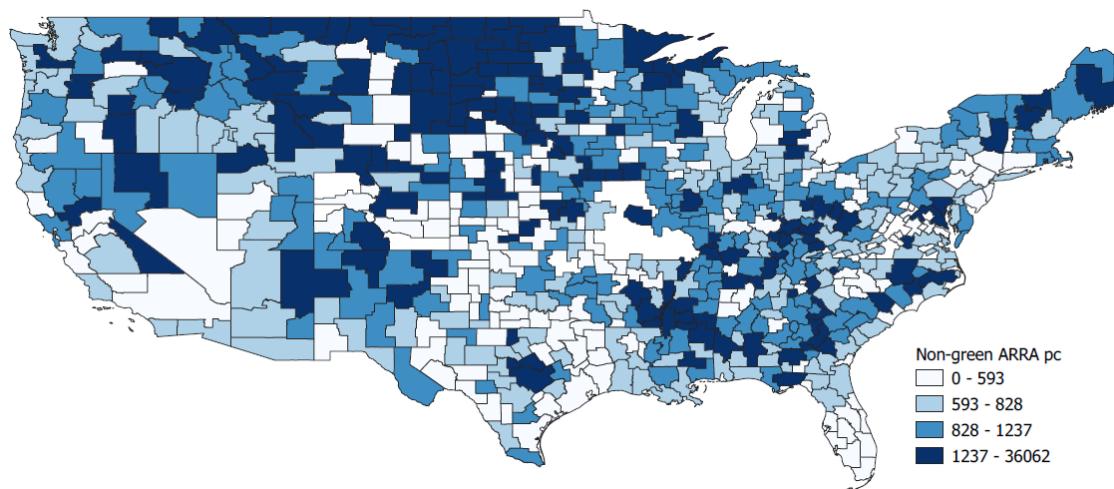- Spending was not homogeneous across different government agencies
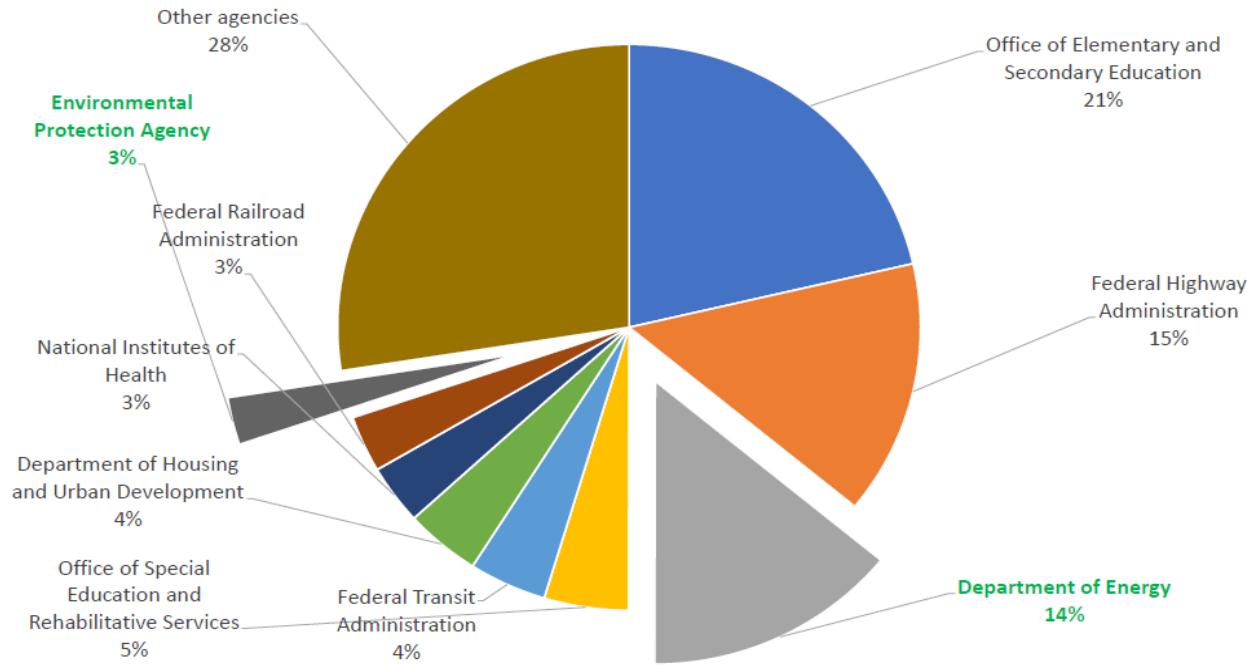
- Thus, not homogeneously spread across different locations
  - Wilson (*AEJ-EP*, 2012): Most funds allocated according to statutory formulas based on exogenous factors such as the number of highway lane-miles in a state or the youth share of its population

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Per capita ARRA funds by commuting zone

Green ARRA

Non-Green ARRA

Non-green ARRA pc
- 0 - 50
- 50 - 104
- 104 - 192
- 192 - 28496

Non-green ARRA pc
- 0 - 593
- 593 - 828
- 828 - 1237
- 1237 - 36062

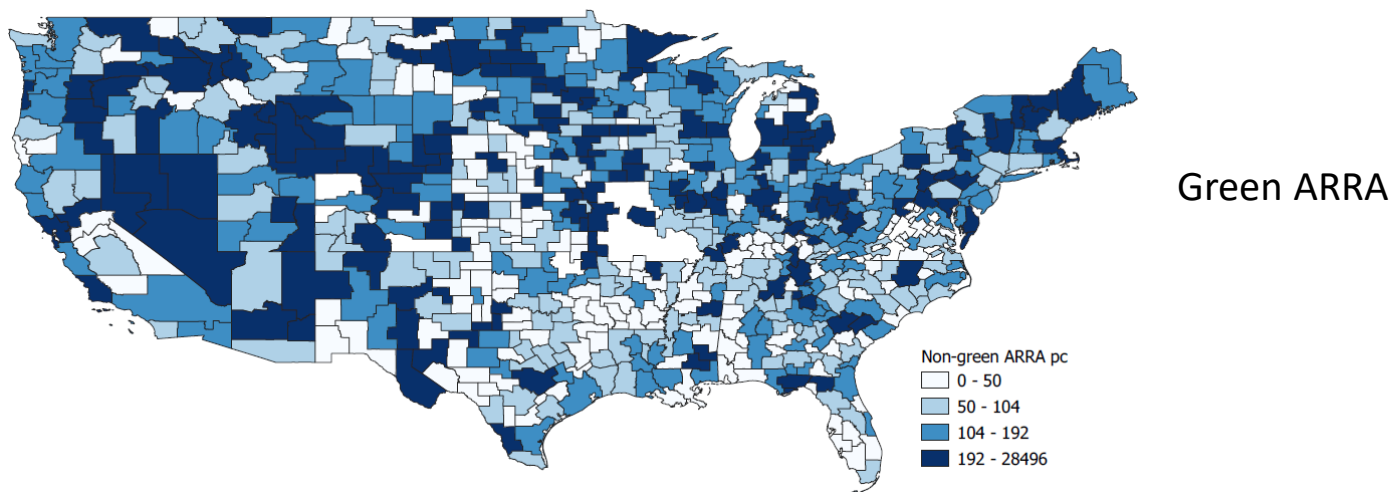David Popp

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Data

- We use the share of green general skills in the local labor force to calculate FTE of workers performing green and non-green tasks in the local labor market
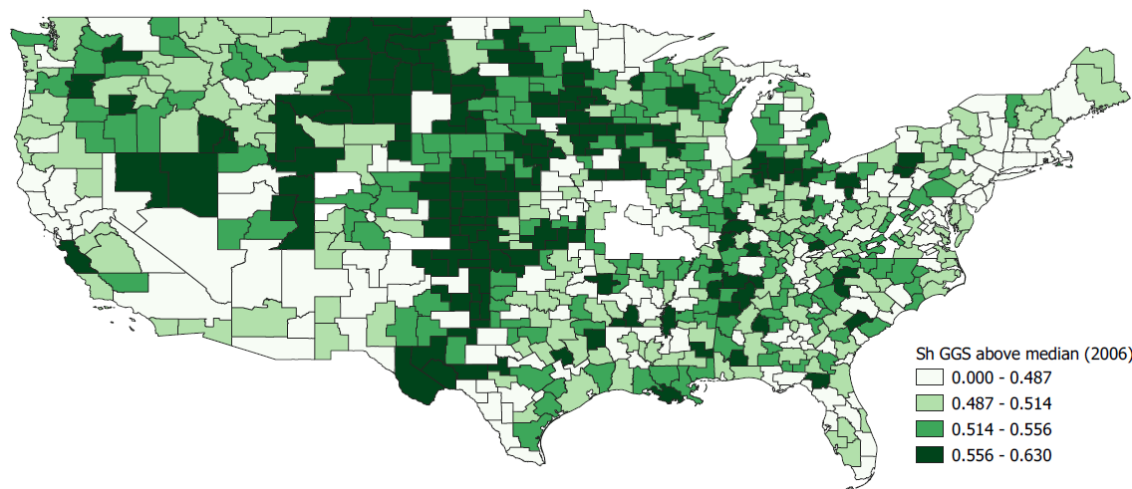
	Mean	SD	Min	Max
Per capita Green employment	0.018	0.007	0.001	0.125
Per capita NonGreen employment	0.375	0.096	0.013	1.662
ARRA spending in million $				
GreenARRA	89.080	287.784	0.000	3677.566
NonGreen ARRA	381.451	926.815	0.114	9963.451

Notes: Per capita levels calculated using population in 2008.

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Per capita ARRA funds by commuting zone

Green ARRA

Non-green ARRA pc
- 0 - 50
- 50 - 104
- 104 - 192
- 192 - 28496

Share of employment,
GGS > median
2006

Sh GGS above median (2006)
- 0.000 - 0.487
- 0.487 - 0.514
- 0.514 - 0.556
- 0.556 - 0.630

Bivariate relationship between ARRA & Green Skills
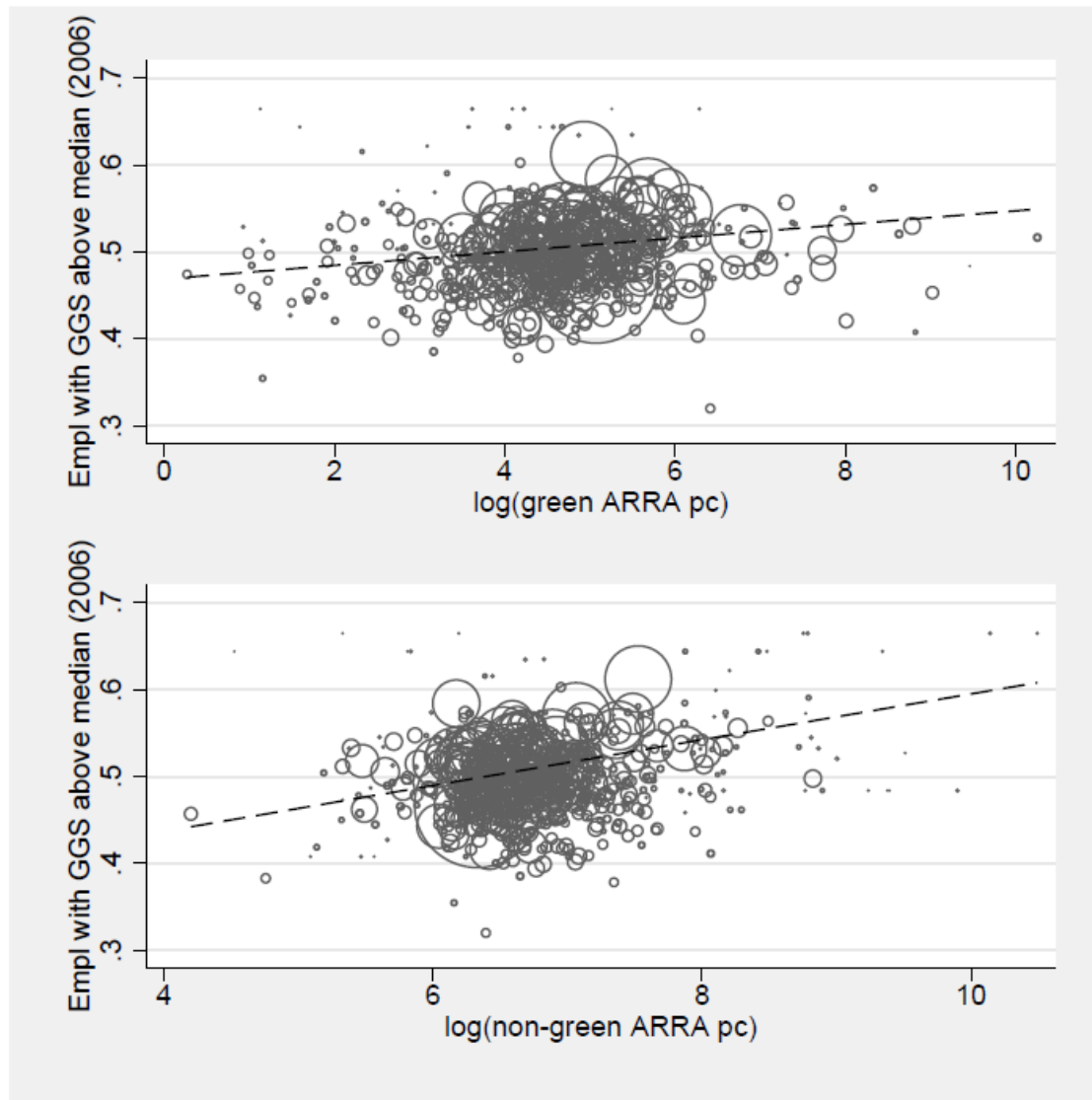
Methodology

- We estimate a stacked long-difference model

$$\Delta log\left(\frac{Y_{i,t-2008}}{pop_{i,2008}}\right) = \beta_0 + \sum_k \gamma_k log\left(\frac{GreenARRA_i}{pop_{i,2008}}\right) + \sum_k \gamma_k log\left(\frac{NonGreenARRA_i}{pop_{i,2008}}\right) +$$

$$\eta\mathbf{OPolicy_{i,t-2008}} + t \cdot \mathbf{X_{i,2005}}'\vartheta + \eta_t + \eta_{t,s} + \epsilon_{i,t}$$

- Outcome variables are changes relative to 2008 levels in:
  - Log of green employment per capita
  - Log of non-green employment per capita

- $GreenARRA_{is}$ and $NonGreenARRA_{is}$ denote the dollar amount of Green and non-Green awards
  - We group into three periods: pre-ARRA (2005-08), ARRA (2009-12), and post-ARRA (2013-17), indexed by k in the equation

- We control for other factors affecting:
  1. the likely impact of stimulus spending
  2. the relative levels of green versus non-green employment

- η_{st} denotes state-by-year fixed effects

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Results

- Neither green nor non-green ARRA have an impact on green jobs

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Green Employment

	Controls X t	Controls	Fixed Effects
ln(Green ARRA p.c.), pre-sample	0.00157	0.00144	0.00226
	[0.00525]	[0.00514]	[0.00519]
ln(Green ARRA p.c.), short-run	0.00201	0.00361	0.00239
	[0.00528]	[0.00510]	[0.00519]
ln(Green ARRA p.c.), long-run	0.00896	0.01127**	0.00906
	[0.00585]	[0.00572]	[0.00568]
ln(Non-green ARRA p.c.), pre-sample	0.01134	-0.01308	0.00496
	[0.01509]	[0.01943]	[0.01542]
ln(Non-green ARRA p.c.), short-run	-0.00370	0.00705	-0.00867
	[0.01628]	[0.01876]	[0.01520]
ln(Non-green ARRA p.c.), long-run	0.00911	0.00901	-0.00350
	[0.02026]	[0.02043]	[0.01777]
N	8892	8892	8892
r2	0.4001	0.3960	0.5081

Standard errors in brackets, clustered by commuting zones. All models include state-by-year fixed effects.
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

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Results

- Neither green nor non-green ARRA have an impact on green jobs

- Consistent with other studies, non-green ARRA has a short-run stimulus effect on non-green employment
  - Magnitude is roughly 4 jobs per $1 million

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Non-green Employment

	Controls X t	Controls	Fixed Effects
ln(Green ARRA p.c.), pre-sample	0.00205*	0.00448***	0.00328***
	[0.00119]	[0.00116]	[0.00108]
ln(Green ARRA p.c.), short-run	-0.00035	-0.00012	0.00090
	[0.00111]	[0.00103]	[0.00108]
ln(Green ARRA p.c.), long-run	0.00341*	0.00578***	0.00628***
	[0.00183]	[0.00205]	[0.00234]
ln(Non-green ARRA p.c.), pre-sample	-0.00006	0.00070	-0.00104
	[0.00268]	[0.00386]	[0.00267]
ln(Non-green ARRA p.c.), short-run	0.00704**	0.00476	0.00762**
	[0.00308]	[0.00303]	[0.00333]
ln(Non-green ARRA p.c.), long-run	-0.00734	-0.00927	-0.00469
	[0.00575]	[0.00587]	[0.00653]
N	8892	8892	8892
r2	0.7074	0.6682	0.7068

Standard errors in brackets, clustered by commuting zones. All models include state-by-year fixed effects.
* p<0.10, ** p<0.05, *** p<0.01

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Results

- Neither green nor non-green ARRA have an impact on green jobs

- Consistent with other studies, non-green ARRA has a short-run stimulus effect
  - Magnitude is roughly 4 jobs per $1 million

- Green ARRA has no short-run effect, but a long-run effect
  - Magnitude is roughly 15 jobs per $1 million
  - However, we also see a significant pre-trend: does green ARRA go where it is needed least?

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Non-green Employment

	Controls X t	Controls	Fixed Effects
ln(Green ARRA p.c.), pre-sample	0.00205*	0.00448***	0.00328***
	[0.00119]	[0.00116]	[0.00108]
ln(Green ARRA p.c.), short-run	-0.00035	-0.00012	0.00090
	[0.00111]	[0.00103]	[0.00108]
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* $p<0.10$, ** $p<0.05$, *** $p<0.01$

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Results by Green Skills

- Does the local skill base matter?

- We divide commuting zones into four quartiles, based on Green General Skill importance

- Green stimulus is most effective in areas with more green skills

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Results by Green Skills

Green employment

	0-25th percentile	25-50th percentile	50-75th percentile	> 75th percentile
ln(Green ARRA p.c.), pre-sample	-0.00491	-0.0004	0.00557	0.00586
	[0.00827]	[0.00784]	[0.00875]	[0.01572]
ln(Green ARRA p.c.), short-run	0.00648	0.00369	0.00155	0.00235
	[0.00650]	[0.00554]	[0.00479]	[0.00592]
ln(Green ARRA p.c.), long-run	0.00629	0.00559	0.01916**	0.01411
	[0.01162]	[0.00844]	[0.00930]	[0.01240]

Non-green employment

	0-25th percentile	25-50th percentile	50-75th percentile	> 75th percentile
ln(Green ARRA p.c.), pre-sample	0.00256*	0.00492***	0.00041	-0.00722
	[0.00151]	[0.00125]	[0.00199]	[0.00670]
ln(Green ARRA p.c.), short-run	0.00055	0.00043	-0.00181	0.00145
	[0.00099]	[0.00096]	[0.00115]	[0.00139]
ln(Green ARRA p.c.), long-run	0.00453	-0.00028	0.00486	0.01251***
	[0.00332]	[0.00272]	[0.00331]	[0.00474]

Next Steps

- Consider other explanations for stimulus funding patterns

- Currently adding data on other federal spending patterns

- Checking for other differential effects
  - Share of employment in brown jobs?
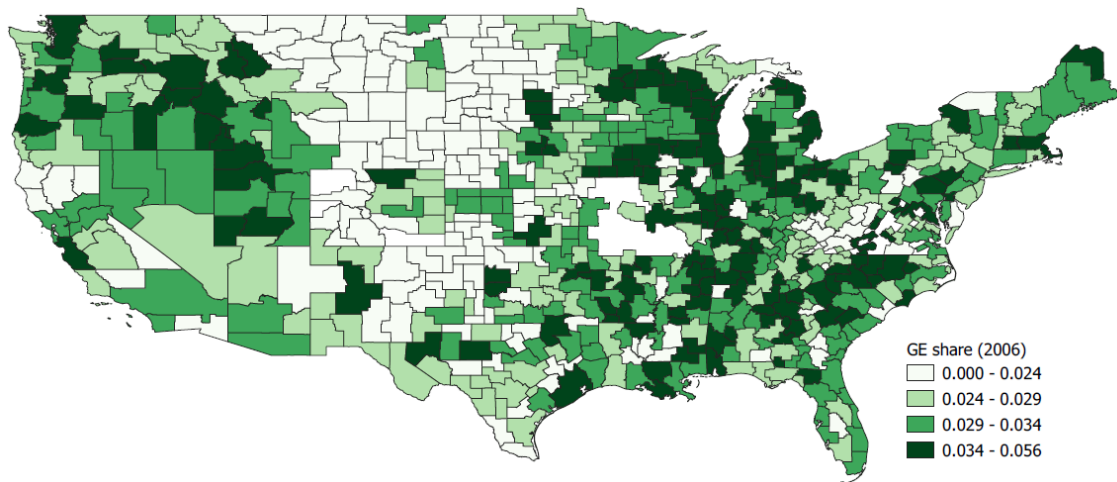 - Share of employment in other occupations?

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Thank You!

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Extra slides

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Examples of Green Occupations

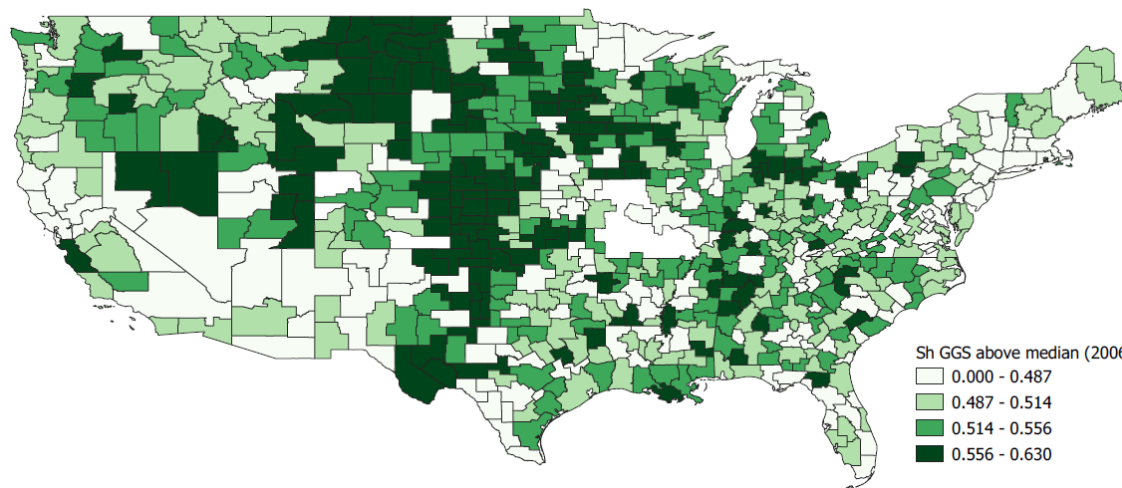|	Greenness < 0.3	0.3 < Greenness < 0.5	Greenness = 1
Green Enhanced Occupations	Construction Workers Maintenance & Repair Workers Inspectors Marketing Managers	Aerospace Engineers Atmospheric & Space Scientists Automotive Speciality Technicians Roofers	Environmental Engineers Environ Science Technicians Hazardous Material Removers
New and Emerging Green Occupations	Traditional Engineering Occupations Transportation Planners Compliance Managers	Electrical Engineering Technologists Biochemical Engineers Supply Chain Managers Precision Agriculture Technicians	Wind Energy Engineers Fuel Cell Technicians Recycling Coordinators

Green jobs and green skills

- Comparing skills in "green" and "brown" jobs (Vona *et al.* 2018)
  - In many cases the skills used in each are comparable
  - Key differences include energy extraction workers
    - Here, the skills required for occupations likely to be affected by environmental regulation differ from those demanded by comparable green jobs
  - Workers in jobs displaced by environmental regulation in these sectors may face particular challenges finding new employment
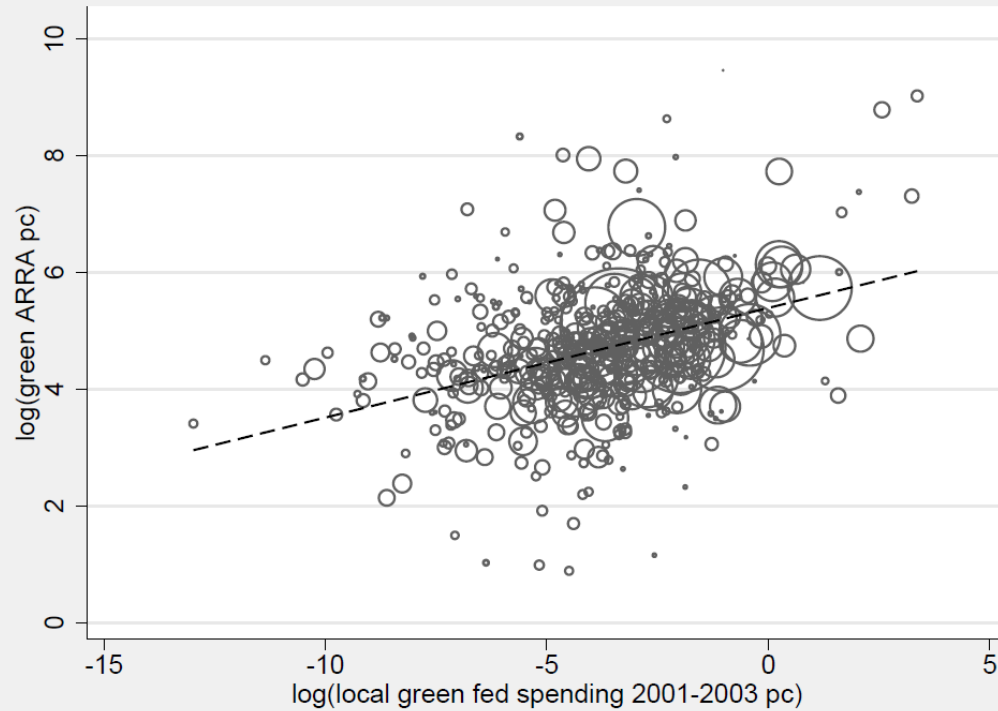
Green employment by commuting zone

Share of green employment, 2006

GE share (2006)
- 0.000 - 0.024
- 0.024 - 0.029
- 0.029 - 0.034
- 0.034 - 0.056

Share of employment,
GGS > median
2006

Sh GGS above median (2006)
- 0.000 - 0.487
- 0.487 - 0.514
- 0.514 - 0.556
- 0.556 - 0.630

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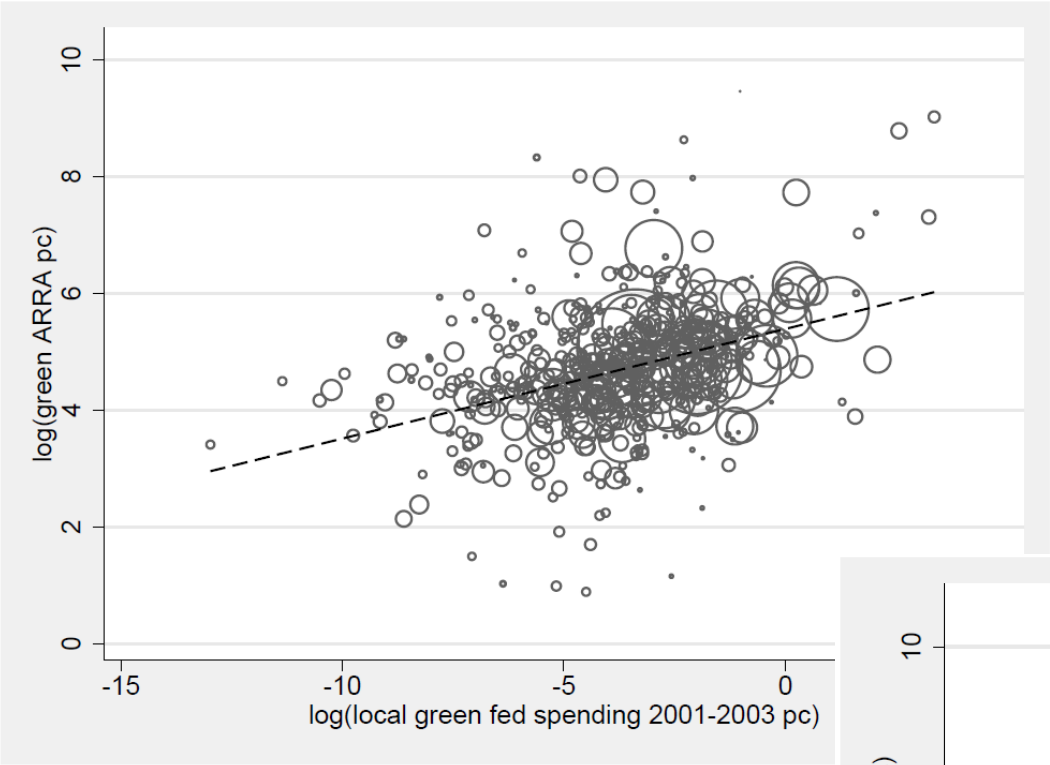
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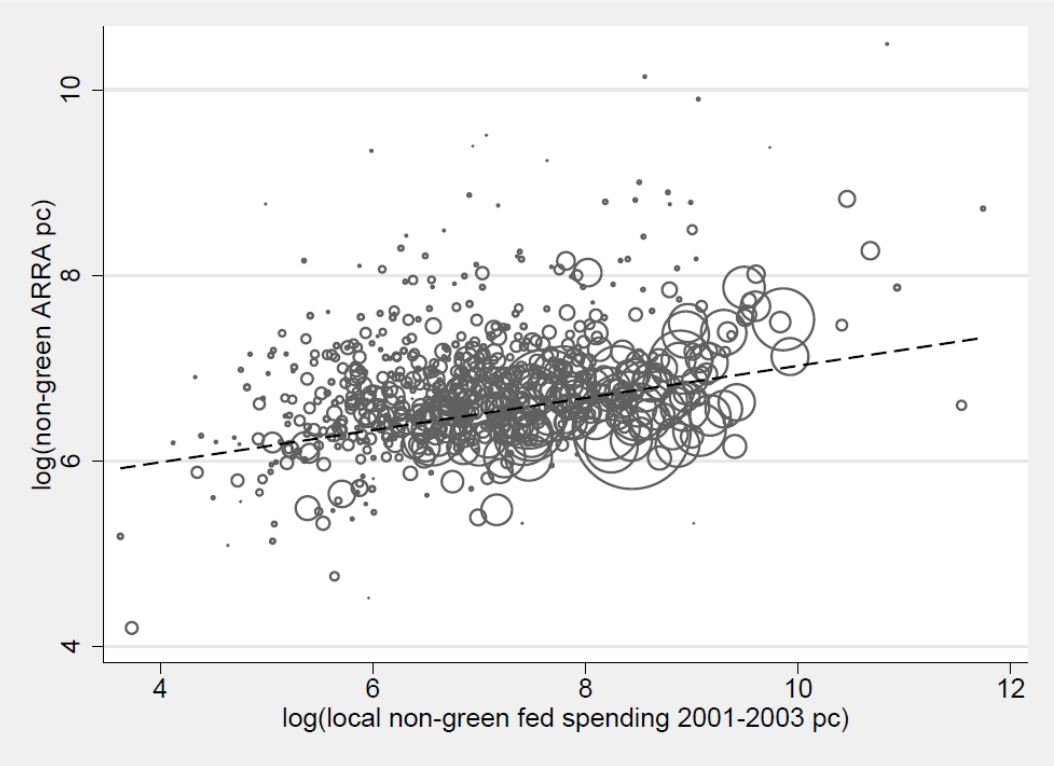# Bivariate relationship between ARRA & federal spending in 2001-2003

Green spending

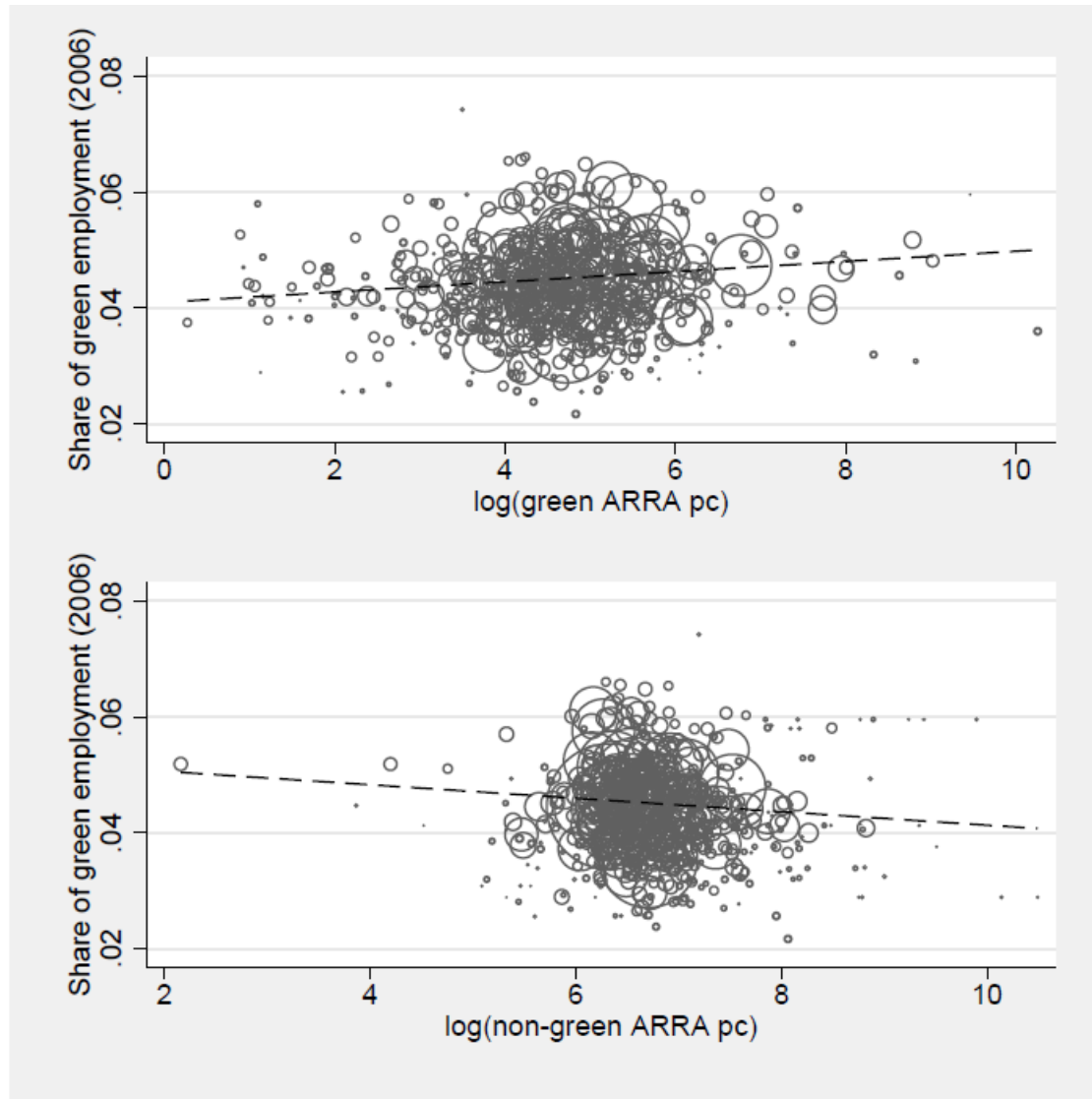# Bivariate relationship between ARRA & federal spending in 2001-2003

Green spending

Non-Green spending

Bivariate relationship between ARRA & Green Skills

Methodology

- We estimate a stacked long-difference model

$$\Delta log \left(\frac{Y_{i,t-2008}}{pop_{i,2008}} \right) = \beta_0 + \sum_k \gamma_k log \left(\frac{GreenARRA_i}{pop_{i,2008}} \right) + \sum_k \gamma_k log \left(\frac{NonGreenARRA_i}{pop_{i,2008}} \right) +$$

$$\eta \mathbf{OPolicy_{i,t-2008}} + t \cdot \mathbf{X_{i,2005}}'\boldsymbol{\vartheta} + \eta_t + \eta_{t,s} + \epsilon_{i,t}$$

- $\mathbf{X}_{t,2005}$: time-invariant controls for initial employment conditions & econoimc structure interacted with time (avoid bad controls)

- We control for other factors affecting:
  1. the likely impact of stimulus spending
     - initial employment levels and growth rates in multiple sectors
     - trade exposure
     - state capitals
  2. the relative levels of green versus non-green employment:
     - potential oil & gas resources and employment in the energy extraction sector
     - patent stocks to proxy for the the green and the general degree of technological specialization of the area
     - Presence of a federally funded Department of Energy lab
     - Environmental policy (varies over time)

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Total Employment

	Controls X t	Controls	Fixed Effects
ln(Green ARRA p.c.), pre-sample	0.00196*	0.00430***	0.00318***
	[0.00111]	[0.00118]	[0.00103]
ln(Green ARRA p.c.), short-run	-0.00021	0.00009	0.00101
	[0.00110]	[0.00103]	[0.00101]
ln(Green ARRA p.c.), long-run	0.00379**	0.00617***	0.00655***
	[0.00186]	[0.00207]	[0.00233]
ln(Non-green ARRA p.c.), pre-sample	0.00059	0.00020	-0.00067
	[0.00254]	[0.00374]	[0.00257]
ln(Non-green ARRA p.c.), short-run	0.00676**	0.00503*	0.00708**
	[0.00296]	[0.00288]	[0.00321]
ln(Non-green ARRA p.c.), long-run	-0.00684	-0.00875	-0.00490
	[0.00571]	[0.00588]	[0.00659]
N	8892	8892	8892
r2	0.7201	0.6807	0.7203

Standard errors in brackets, clustered by commuting zones. All models include state-by-year fixed effects.
* $p<0.10$, ** $p<0.05$, *** $p<0.01$

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