The Employment Impact of Green Fiscal Push: Evidence from the American Recovery and Reinvestment Act

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OECD-EAERE pre-conference workshop
"The joint environmental, social and economic impacts of environmental policies"
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The New York Times

Biden Team Prepares $3 Trillion in New Spending for the Economy

A pair of proposals would invest in infrastructure, education, work force development and fighting climate change, with the aim of making the economy more productive.

By Jim Tankersley

Published March 22, 2021 Updated May 12, 2021

That plan would spend heavily on clean energy deployment and the development of other "high-growth industries of the future" like 5G telecommunications. It includes money for rural broadband, advanced training for millions of workers, and one million affordable and energy-efficient housing units. Documents suggest it will include nearly $1 trillion in spending on the construction of roads, bridges, rail lines, ports, electric vehicle charging stations, and improvements to the electric grid and other parts of the power sector.

https://www.nytimes.com/2021/03/22/business/biden-infrastructure-spending.html

Biden's Lesson From Past Green Stimulus Failures: Go Even Bigger

As vice president, Joe Biden oversaw a "green jobs" stimulus package that produced notable failures. This time, with more money and more demand for clean technology, will be different, Democrats say.

By Coral Davenport

Published March 29, 2021 Updated March 31, 2021

Now, 12 years later, President Biden is preparing the details of a new, vastly larger, economic stimulus plan that again would use government spending to unite the goals of fighting climate change and restoring the economy. While clean energy spending was just a fraction of the Obama stimulus, Mr. Biden wants to make it the centerpiece of his proposal for trillions of dollars, not billions, on government grants, loans, and tax incentives to spark renewable power, energy efficiency and electric car production.

https://www.nytimes.com/2021/03/29/climate/biden-climate-stimulus.html

Aim

- Our paper estimates the **effect** of **green stimulus** from the American Recovery and Reinvestment Act (**ARRA**) of 2009 on **local employment**
- We provide evidence for **heterogeneous effects** based on:
  - Pre-existing green **skills** in a region
  - **Types of workers** ⇒ manual labor positions benefited most
  - **Sectors** ⇒ most jobs created were in **construction**

Outline of the presentation

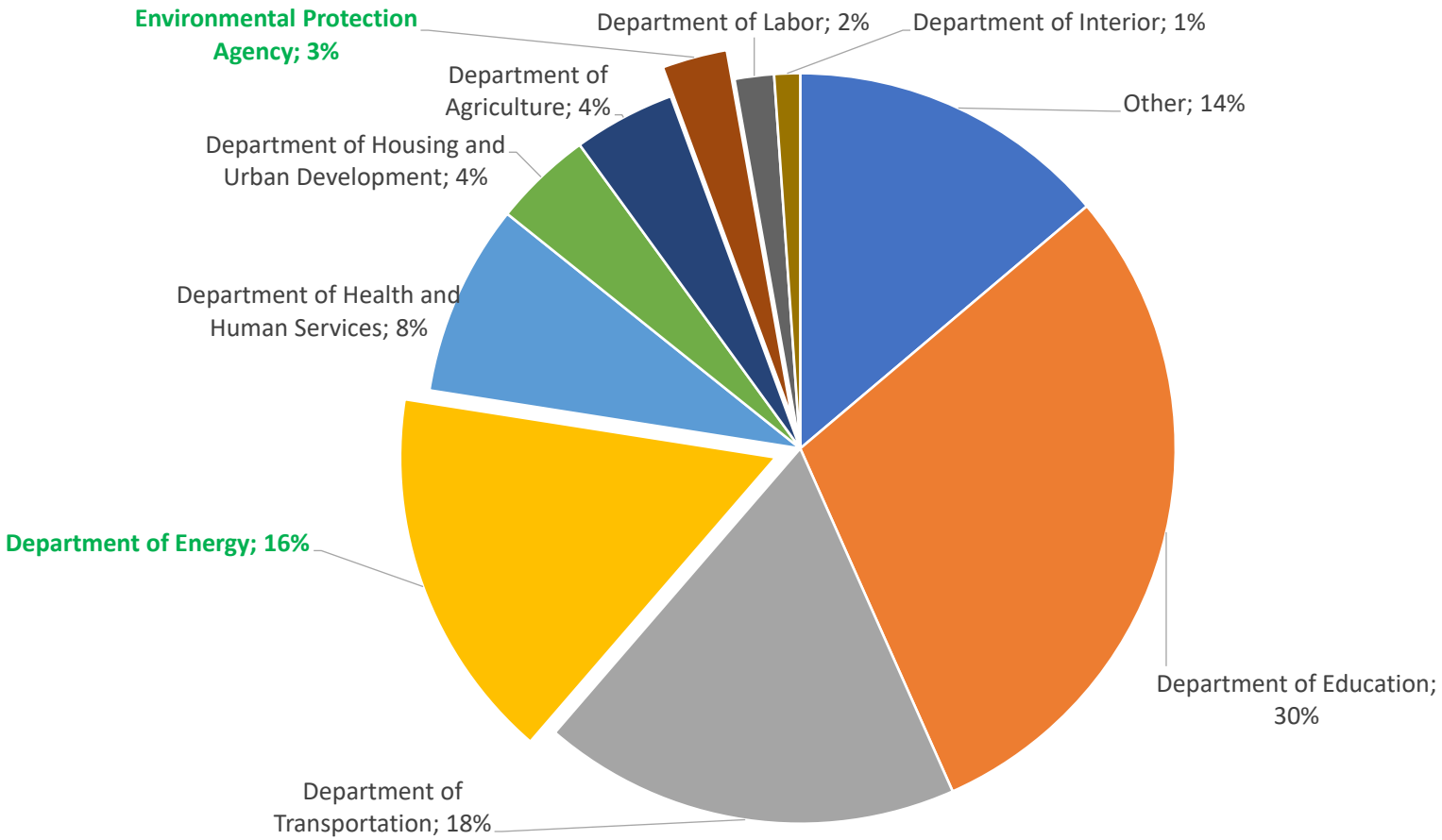
Policy-relevance

- Political interest for the design of **recovery packages** after COVID-19 lockdowns and as part of the **European Green Deal** (and **Next Generation EU**) proposed by the new Biden US administratin, the European Commission, the International Energy Agency and the International Monetary Fund (Helm, ERE 2020)
  - Our results point to **significant** (but **moderate**) **job creation effects**, mostly in the **long(er) run** and in **manual** occupations
- A focus on **skills** informs how easy it may be for **individuals losing jobs** to find **new employment** in potentially very **different sectors**
  - Many studies find **small effects** of **environmental regulation** on employment (Morgenstern et al., JEEM 2002; Hafstead and Williams, JPubEcon 2018; Metcalf and Stock, AER P&P 2020)
  - But concentrated in **polluting sectors** (Kahn and Mansur, JPubEcon 2013) and **low-skilled** workers particularly affected (Yip, JEEM 2018; Marin and Vona, JEEM 2019)

The American Recovery and Reinvestment Act

- Between **2007Q4** and **2009Q2** (just 6 quarters) the **GDP** of the US **declined** by **3.98%**
- At the very bottom of what was then labelled as the **Great Recession**, the US newly elected administration approved the **American Recovery and Reinvestment Act** (**February 2009**)
- The aim was to use a **fiscal stimulus** to halt the decline of GDP and to create new jobs
- Overall, the stimulus (public spending + tax cuts) was estimated to amount to about **800 billions USD** (more than 5% of US GDP)
- Spending was **not homogeneous** across different **Departments** and **Agencies** and (as a consequence) was not homogeneously spread across different **locations**

Figure: Distribution of ARRA by Department/Agencies



How were ARRA funds allocated to different areas?

- **Wilson (2012 AEJ-EP)**
  - "*Most of these funds were 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*"
  - **Department of Labor**'s spending is primarily sent to **state governments** to pay for **extended unemployment insurance** benefits ⇒ **not reported** in Recovery.gov and driven by the **change** in the **state's unemployment** rate
  - "*In essence, the ARRA just* stepped up the funding *amounts* without altering *the* allocation *mechanism*"
- **Serrato and Wingender (2010)**
  - "Much **federal spending** is **allocated based on population estimates** that are **exogenously shocked** after each **Decennial Census**"

Fiscal stimulus and job multipliers: related literature

- **Wilson (2012 AEJ-EP)** exploits **cross state variations** in ARRA spending to estimate the effects of ARRA on employment ⇒ **$125,000** spent per each **additional job** created
- **Feyrer and Sacerdote (2011)** ⇒ **$107,000** spent per each additional **job** created
- **Dupor and Mekhari (2016 EER)** ⇒ **$100K** increases **employment** by **0.95 job-years**
- **Dupor and McCrory (2018 EJ)** ⇒ **$100K** increases **employment** by **1.03** and **0.85** job-years in own and **neighbouring subregion** jobs, respectively, and increases **wages** by **$64K** and **$50K**, respectively
- **Garin (2019 J Urb Econ)** ⇒ **local multiplier** effect of **infrastructure-related** ARRA spending
  - Funds allocated to **'shovel ready' projects** that were **already planned** ⇒ **no targeting** based on job losses
  - **One USD** of 'construction' ARRA generates **30 cents of payroll** in the five subsequent years
- **Vona et al. (2019)** ⇒ **large (about 4) green job local multiplier** for US metro and nonmetro areas

Expected local job-related impacts of fiscal stimulus

- Increase local employment and wages in the **targeted sectors** (+)
  - As **labour** is **immobile** in the **short run**, the short run effect is due to increased labour market **participation** or decreased **unemployment**
- **Crowd out** employment in other sectors through **increasing cost of labour** (-)
  - In the **long run labour** could **migrate** in response for increasing labour demand
- Increase employment in **other sectors** through **increasing consumption** of all goods and services (+)

Research questions

1. To what extent did the **'green' component** of the **ARRA** influence **local labour market outcomes**?
2. Was the impact of green ARRA **'(green) skill-biased'**?
3. Did the existing **endowment** of **green skills** ease job creation from green ARRA?

ARRA spending: data sources

American Recovery and Reinvestment Act

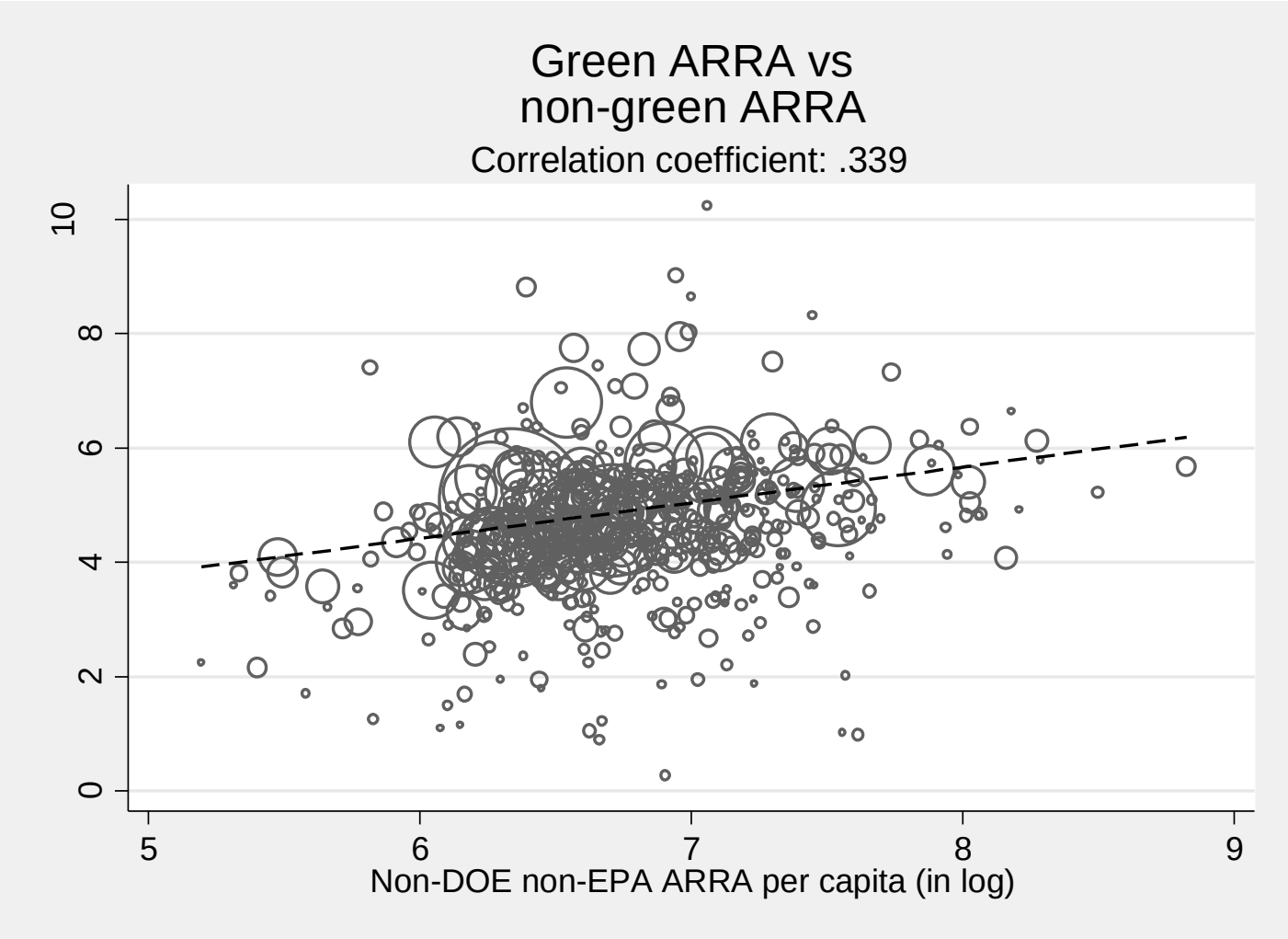
- **Data** about **ARRA** spending was published on the website https://www.recovery.gov (later discontinued) ⇒ data on **individual awards** now available at **NBER** https://www.nber.org/data/ARRA/
- **Local spending** is allocated to the different **place of performance** (of prime and sub-prime recipients) ⇒ some of the funds were allocated to states (and consequently to state capitals)
- Data are **broken down** by **Department/Agency**

Data are allocated to **709 Commuting Zones** (groups of counties) as defined in Dupor and Mehkari (2014) ⇒ focus on CZ with population >25k (>99% of US population; we exclude New Orleans LA, outlier because of Katrina Hurricane)

'Green' ARRA: definition

- We define '**green ARRA**' as the ARRA-related spending awarded or funded by either the **Department of Energy** (DoE) or the **Environment Protection Agency** (EPA) ⇒ overall **19%** of all **ARRA**
  - **DoE example**: "*Abengoa Solar Inc.'s Solana project [1.36 billions USD], will be the* world's largest parabolic trough concentrating solar plant. *Located near Gila Bend, Arizona, the 250-megawatt (MW) project is the first large-scale solar plant in the United States capable of storing energy it generates. [...] the Solana project will* create between 1,600 to 1,700 new construction jobs and over 60 permanent jobs." (source: DoE)
  - **EPA example**: "*The award [433 millions USD] provides funding under the ARRA of 2009 to the State of New York [...] for the* construction of wastewater treatment facilities and associated infrastructure, *green infrastructure, nonpoint source projects, estuary projects and program administration. The* primary purposes *of the award are to:* preserve and create jobs and promote economic recovery *through the investment in infrastructure protects that will* improve water quality *and will provide* long-term economic benefits." (source: EPA)

Figure: Green vs non-green ARRA per capita by commuting zones



Labour market outcomes: data sources

- **Employment** by industry from **BLS QCEW** (Quarterly Census on Employment and Wages)
- We retrieve information on **labour market outcomes** from the **1% sample** of the annual **American Community Survey** (ACS) from **IPUMS** (Integrated Public Use Microdata Series)
- Working-age population (16-64 yo)
- Detailed information on **location**, **wages**, **income**, **occupation**, etc
- **Occupational tasks and skills** data to build **GGS indicators** and to compute **green employment** are retrieved from **O*NET**
- Coverage: **2005-2017**

Baseline specifications

- We estimate the **relationship** between **local spending** in the **green** component of **ARRA** and **labour market outcomes**
- Our **specification** is:

$$
\begin{aligned}
Y_{i,t} - Y_{i,t=2008} &= \sum_{\tau} \gamma_{\tau} log(G\_ARRA\_pc_i) + \\
&+ \sum_{\tau} X_{i,t_0} \psi_{\tau} + \mu_{i \epsilon v,t} + \eta_{i \epsilon r,t} + \varepsilon_{i,t} \\
\text{with} \quad & \tau \in \{\text{2005-07, 2008-12, 2013-17}\}
\end{aligned}
$$

where:

- Y represents the **labour market outcome** variables
- $log(G\_ARRA\_pc_i)$ represents **green ARRA** local spending **per capita**
- X_i' is a vector of **time-invariant** control variables (measured in 2005)
- $\mu_{i \epsilon v,t}$ are period-specific dummies for CZ belonging to **vigintile** v of non-green ARRA per capita
- $\eta_{i \epsilon r,t}$ are period-specific **state** dummies

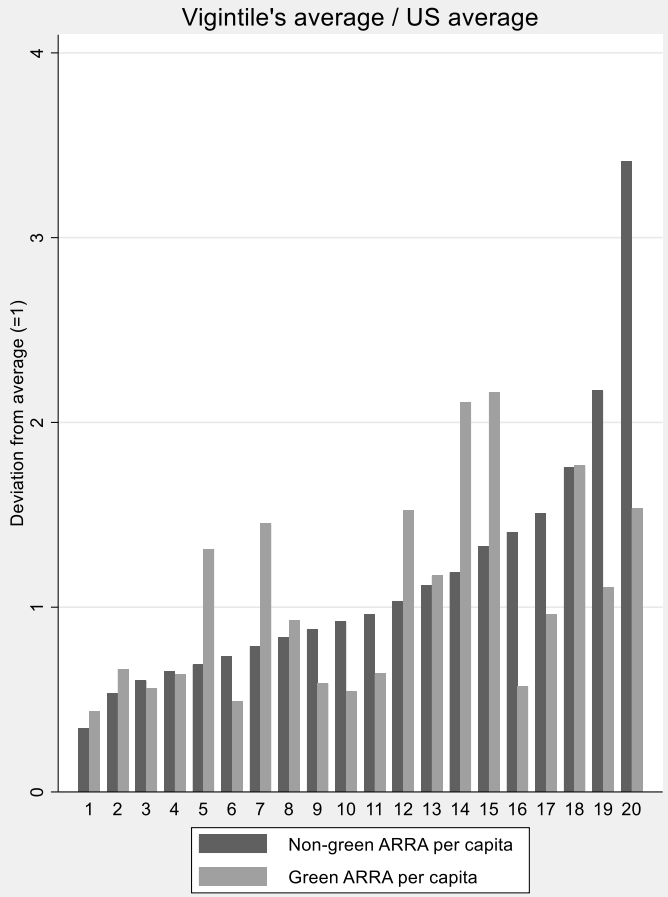
Estimation issues

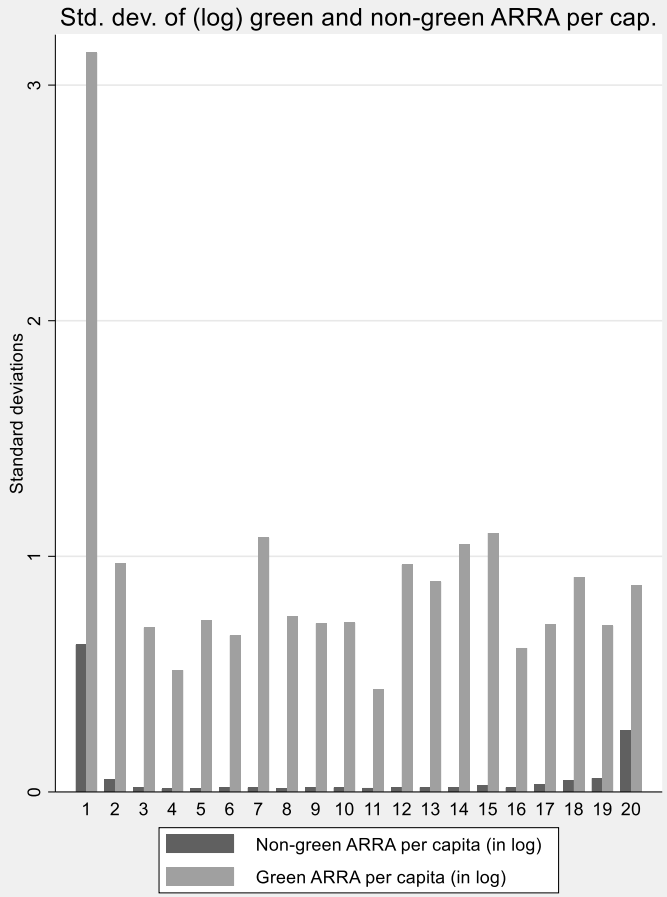
- **Criteria** to **allocate** green spending **unknown** by the researcher ⇒ Two sources of **endogeneity**:
  - ARRA spending targets **areas hardest hit** by the recession and is endogenous by construction
  - **Long-term goals** very **important** particularly for **green** ARRA
- **Non-random assignment** ⇒ green ARRA positively associated with **structural characteristics** correlated with **employment growth**, such as the presence of a federal R&D laboratory, manufacturing and construction employment, and green skills
- Presence of **pre-trends** ⇒ employment **growth before** the **crisis** positively associated with green ARRA spending
- Moreover, effects may be highly **heterogeneous** depending on the green **skills** or types of workers available in different CZs

Non-random assignment

- We include **vigintiles** of **non-green ARRA** to account for correlated non-green spending in a **flexible** way
- Including vigintiles of non-green ARRA is **not enough** to **eliminate differences** in observable characteristics correlated with green ARRA spending
- **CZs** receiving more **green subsidies** stronger in terms of **technological expertise** (green skills, share of manufacturing employment, presence of a federal R&D lab)
- We **control** for other factors:
  - Capturing the **economic conditions** in a CZ before the Great Recessions used in previous ARRA evaluations (e.g., the level and pre-trends (2005-2007) in unemployment, employment in different sectors, etc.)
  - Specific to the **green economy** such as nonattainment designation under the CAA, wind and solar potential, shale gas sites and the index of the green skills of the workforce

Vigintiles of non-green ARRA





Pre-trends

Dep var: Change in log employment per capita compared to 2008	(1)	(2)	(3)	(4)	(5)	(6)
			Total Employment			
Green ARRA per capita (log)	0.0010	0.0016	0.0026***	0.0009	0.0016*	0.0027***
	(0.0014)	(0.0011)	(0.0009)	(0.0011)	(0.0009)	(0.0008)
Non-green ARRA per capita (log)				0.0103**	0.0077**	-0.0002
				(0.0041)	(0.0030)	(0.0032)
R-squared	0.5129	0.5904	0.6871	0.4927	0.5738	0.6786
			Green Employment			
Green ARRA per capita (log)	-0.0021	-0.0003	0.00001	-0.0016	-0.0001	0.0011
	(0.0043)	(0.0043)	(0.0044)	(0.0051)	(0.0051)	(0.0052)
Non-green ARRA per capita (log)				0.0023	-0.0020	-0.0033
				(0.0162)	(0.0145)	(0.0163)
R-squared	0.1585	0.1808	0.2496	0.1352	0.1579	0.2261
			Manual Labor Employment			
Green ARRA per capita (log)	-0.0016	-0.0004	0.0008	-0.0019	-0.0005	0.0015
	(0.0031)	(0.0028)	(0.0027)	(0.0026)	(0.0024)	(0.0021)
Non-green ARRA per capita (log)				0.0153	0.0104	-0.0016
				(0.0092)	(0.0078)	(0.0081)
R-squared	0.3022	0.3520	0.4536	0.2802	0.3340	0.4355
US Census Division fixed effecs	No	Yes	No	No	Yes	No
State fixed effecs	No	No	Yes	No	No	Yes
Vigintiles of non-green ARRA per capita	Yes	Yes	Yes	No	No	No
N of CZ	587	587	587	587	587	587
Observations	1761	1761	1761	1761	1761	1761

Notes: OLS model weighted by CZ population in 2008. Sample: CZ with at least 25,000 residents in 2008. Timespan: 2005-2007. Year dummies included in all specifications. Control variables as in Table 1: Share of empl with GGS>p75 (year 2006), Population 2008 (log), Income per capita (2005), Import penetration (year 2005), Pre trend (2000-2007) empl manufacturing / pop, Pre trend (2000-2007) employment tot / pop, Pre trend (2000-2007) empl constr / pop, Pre trend (2000-2007) empl extractive / pop, Pre trend (2000-2007) empl public sect / pop, Pre trend (2000-2007) unempl / pop, Pre trend (2000-2007) empl edu health / pop, Empl manuf

Dealing with pre-trends

- We **explicitly test** and **account** for the resence of pre-trends
- As long as **green ARRA** per capita is **not** (conditionally) **correlated** with **pre-ARRA trends** (i.e. $\hat{\gamma}_{\tau=2005-07} = 0$), $\hat{\gamma}_{\tau=2008-12}$ is the short-term effect while $\hat{\gamma}_{\tau=2013-17}$ is the long-term effect
- $\hat{\gamma}_{\tau=2005-07} \neq 0$ reflects the presence of **unobserved variables correlated** with both **green ARRA** and our **outcome** variables
- We compute the long- and short-term effect of green ARRA by **subtracting** its **effect before 2008**
- $\hat{\gamma}_{\tau=2008-12} - \hat{\gamma}_{\tau=2005-07}$ and $\hat{\gamma}_{\tau=2017-13} - \hat{\gamma}_{\tau=2005-07}$ can be **interpreted** as the **average effect** of green ARRA in the short- or long-run

Table 3 – Baseline results

Dep var: Change in log employment (by type) per capita compared to 2008	Total employment	Green employment	Manual occupations
Green ARRA per capita (log) x D2005_2007	0.0026***	0.00001	0.0008
	(0.0009)	(0.0043)	(0.0027)
Green ARRA per capita (log) x D2009_2012	0.0026***	0.0040	0.0057**
	(0.0008)	(0.0039)	(0.0022)
Green ARRA per capita (log) x D2013_2017	0.0045***	0.0120**	0.0108**
	(0.0016)	(0.0050)	(0.0046)
Jobs created, $1 million green ARRA:			
Pre-ARRA (2005-2007)	11.53***	0	0.92
	(3.85)	(0.87)	(2.98)
Short-run (2009-2012)	11.15***	0.78	5.48**
	(3.29)	(0.76)	(2.10)
Long-run (2013-2017)	20.8***	2.66**	11.34**
	(7.37)	(1.11)	(4.80)
Short-run - pre-ARRA	0.03	0.78	4.7
	(3.49)	(1.49)	(3.39)
Long-run - pre-ARRA	8.92	2.66	10.48*
	(8.02)	(1.83)	(5.46)
R squared	0.7672	0.4159	0.5749
Observations	7631	7631	7631
F-stat of excluded instruments for IV			

Notes: Regressions weighted by CZ population in 2008. Sample: 587 CZ with at least 25,000 residents in 2008. Year fixed effects and state x period fixed effects included. Additional control variables (interacted with D2002_2007, D2009_2012 and D2013_2017 dummies): Vigintiles of non-green ARRA per capita, Share of empl with GGS>p75 (2005), Population 2008 (log), Income per capita (2005), Import penetration (year 2005), Pre trend (2000-2007) empl manufacturing / pop, Pre trend (2000-2007) employment tot / pop, Pre trend (2000-2007) empl constr / pop, Pre trend (2000-2007) empl extractive / pop, Pre trend (2000-2007) empl public sect / pop, Pre trend (2000-2007) unempl / pop, Pre trend (2000-2007) empl edu health / pop, Empl manuf (average 2006-2008) / pop, Empl constr (average 2006-2008) / pop, Empl extractive (average 2006-2008) / pop, Empl public sect (average 2006-2008) / pop, Unempl (average 2006-2008) / pop, Empl edu health (average 2006-2008) / pop, Shale gas extraction in CZ interacted with year dummies, Potential for wind energy interacted with year dummies, Potential for photovoltaic energy interacted with year dummies, Federal R&D lab, CZ hosts the state capital, Nonattainment CAA old standards, Nonattainment CAA new standards. Endogenous variable (columns 3 and 4): Green ARRA per capita (log). Excluded IV from the first stage: shift-share IV of ARRA spending by Department/Agency; local spending share 2001-2004. Standard errors clustered by state in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

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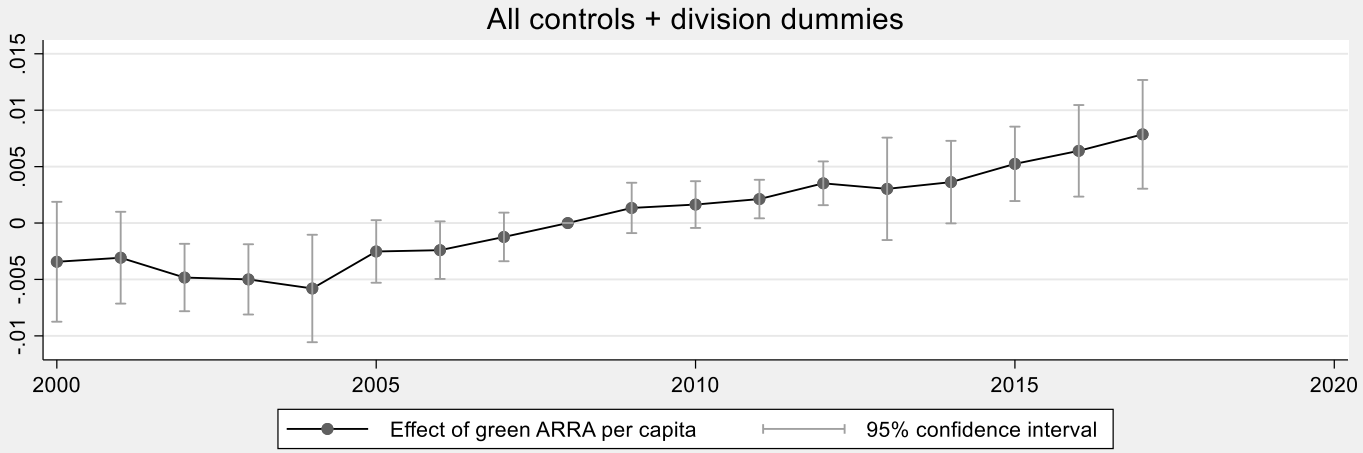
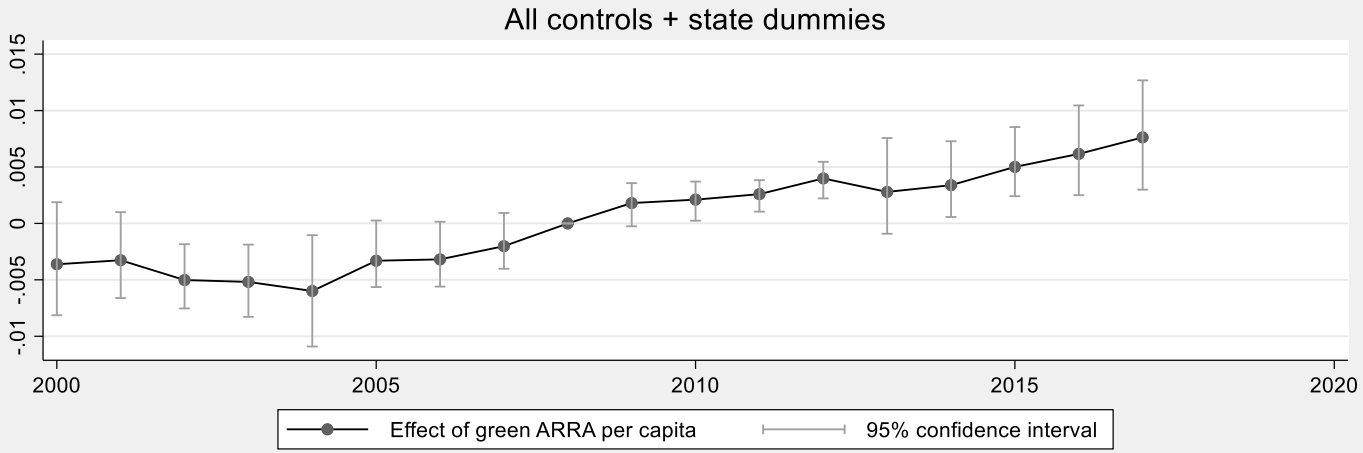
Figure: Year-by-year effect for total employment

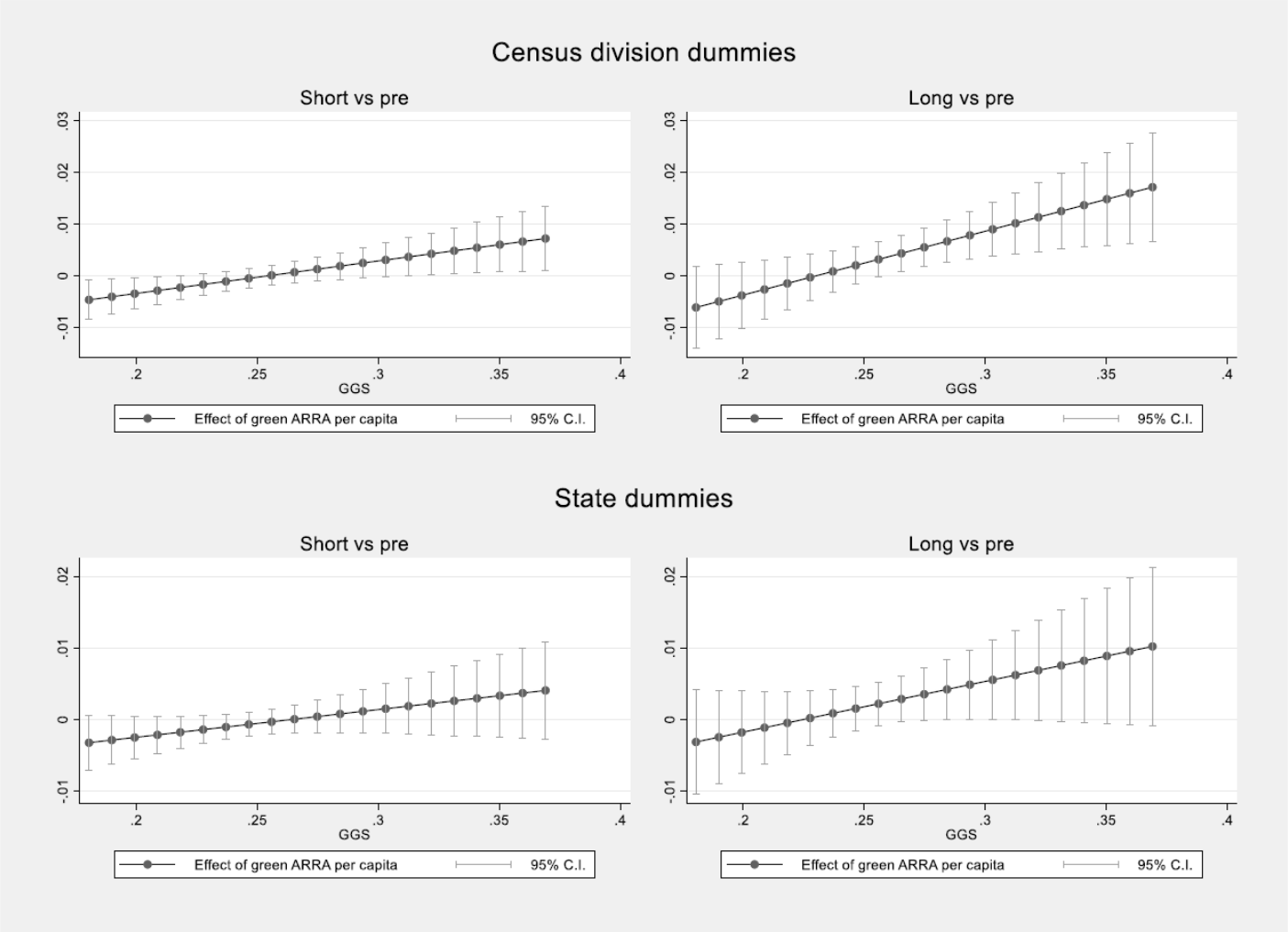




Why delayed effects?

- **Leveraging** and **crowding-in**
  - Anecdotal evidence that **green ARRA** attracted **substantial private investment** (Mundaca and Richter, 2015)
- **Administrative requirements** slowed progress (Carley et al. 2014, Carley 2016)
  - **Guidelines unclear** at beginning of program
  - Need to **comply** with **local regulations**
  - Programs **not easy to administer**
    - Many **reporting requirements**
    - **Buy American** requirements – some products hard to find
    - **Need sufficient staff** to spend sudden influx of money
- Our contribution $\Rightarrow$ **reducing skill mismatches** is **important** to ensure a smooth **reallocation** of workers

Figure 7 – Variation in the Effect of Green ARRA on employment by initial Green Skills



Robustness checks

- Excluding **2009**
- Excluding **1st** and **20th vigintiles**
- Excluding CZs hosting federal **R&D labs**
- Including CZs with less than **25k residents**
- Excluding **energy R&D** from ARRA
- Excluding **DoE loans**
- Exclude **all loans**
- Exclude all **contracts** (i.e. procurement)
- **Grants** only
- **Census division** instead of state fixed effects
- From 4 to 20 **quantiles**
- **IV**: shift-share based on pre-ARRA local spending by Department/Agency (but weak IV...)

Table 5 – Results by sector

Dep var: Change in log employment (by type) per capita compared to 2008	Green employment	Manufacturing sector (NAICS 31-33)	Construction sector (NAICS 23)	Support services including waste management (NAICS 56)
Green ARRA per capita (log) x D2005_2007	0.00001	0.0057***	-0.0017	-0.0063
	(0.0043)	(0.0021)	(0.0032)	(0.0131)
Green ARRA per capita (log) x D2009_2012	0.0040	0.0037**	0.0035	0.0136
	(0.0039)	(0.0016)	(0.0032)	(0.0086)
Green ARRA per capita (log) x D2013_2017	0.0120**	0.0069*	0.0143***	0.0063
	(0.0050)	(0.0040)	(0.0052)	(0.0097)
Jobs created, $1 million green ARRA:				
Pre-ARRA (2005-2007)	0	2.86***	-0.43	-1.65
	(0.87)	(1.05)	(0.81)	(3.43)
Short-run (2009-2012)	0.78	1.54**	0.65	3.2
	(0.76)	(0.65)	(0.61)	(2.03)
Long-run (2013-2017)	2.66**	2.98*	3.02***	1.69
	(1.11)	(1.73)	(1.10)	(2.61)
Short-run - pre-ARRA	0.78	-0.81	0.98	4.68*
	(1.49)	(0.94)	(1.04)	(2.78)
Long-run - pre-ARRA	2.66	0.53	3.39**	3.39
	(1.83)	(2.35)	(1.28)	(3.20)
R squared	0.4159	0.5514	0.7039	0.2345
Observations	7631	7631	7631	7631

Notes: OLS model weighted by CZ population in 2008. Sample: 587 CZ with at least 25,000 residents in 2008. Year fixed effects and state x period fixed effects included. Additional control variables (interacted with D2002_2007, D2009_2012 and D2013_2017 dummies) same as Table 3. Standard errors clustered by state in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 5 – Results by sector

Dep var: Change in log employment (by type) per capita compared to 2008	Green employment	Manufacturing sector (NAICS 31-33)	Construction sector (NAICS 23)	Support services including waste management (NAICS 56)
Green ARRA per capita (log) x D2005_2007	0.00001	0.0057***	-0.0017	-0.0063
	(0.0043)	(0.0021)	(0.0032)	(0.0131)
Green ARRA per capita (log) x D2009_2012	0.0040	0.0037**	0.0035	0.0136
	(0.0039)	(0.0016)	(0.0032)	(0.0086)
Green ARRA per capita (log) x D2013_2017	0.0120**	0.0069*	0.0143***	0.0063
	(0.0050)	(0.0040)	(0.0052)	(0.0097)
Jobs created, $1 million green ARRA:				
Pre-ARRA (2005-2007)	0	2.86***	-0.43	-1.65
	(0.87)	(1.05)	(0.81)	(3.43)
Short-run (2009-2012)	0.78	1.54**	0.65	3.2
	(0.76)	(0.65)	(0.61)	(2.03)
Long-run (2013-2017)	2.66**	2.98*	3.02***	1.69
	(1.11)	(1.73)	(1.10)	(2.61)
Short-run - pre-ARRA	0.78	-0.81	0.98	4.68*
	(1.49)	(0.94)	(1.04)	(2.78)
Long-run - pre-ARRA	2.66	0.53	3.39**	3.39
	(1.83)	(2.35)	(1.28)	(3.20)
R squared	0.4159	0.5514	0.7039	0.2345
Observations	7631	7631	7631	7631

Notes: OLS model weighted by CZ population in 2008. Sample: 587 CZ with at least 25,000 residents in 2008. Year fixed effects and state x period fixed effects included. Additional control variables (interacted with D2002_2007, D2009_2012 and D2013_2017 dummies) same as Table 3. Standard errors clustered by state in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

Table 6 – Results by occupational group

Dep var: Change in log employment (by occupational group) per capita compared to 2008	Manual occupations	Abstract occupations	Service occupations	Clerical occupations
Green ARRA per capita (log) x D2005_2007	0.0008	0.0036**	0.0025	0.0040*
	(0.0027)	(0.0017)	(0.0027)	(0.0022)
Green ARRA per capita (log) x D2009_2012	0.0057**	0.0006	-0.0017	-0.0005
	(0.0022)	(0.0020)	(0.0033)	(0.0026)
Green ARRA per capita (log) x D2013_2017	0.0108**	-0.0017	0.0001	0.0019
	(0.0046)	(0.0044)	(0.0041)	(0.0027)
Jobs created, $1 million green ARRA:				
Pre-ARRA (2005-2007)	0.92	5.28**	1.82	4.51*
	(2.98)	(2.47)	(1.97)	(2.49)
Short-run (2009-2012)	5.48**	0.98	-1.29	-0.51
	(2.10)	(3.07)	(2.53)	(2.75)
Long-run (2013-2017)	11.34**	-2.84	0.08	1.96
	(4.80)	(7.24)	(3.36)	(2.84)
Short-run - pre-ARRA	4.7	-4.43	-3.22	-4.69
	(3.39)	(5.12)	(4.16)	(4.75)
Long-run - pre-ARRA	10.48*	-8.79	-1.99	-2.24
	(5.46)	(8.53)	(4.84)	(4.69)
R squared	0.5749	0.5846	0.4747	0.4112
Observations	7631	7631	7631	7631

Notes: OLS model weighted by CZ population in 2008. Sample: 587 CZ with at least 25,000 residents in 2008. Year fixed effects and state x period fixed effects included. Additional control variables (interacted with D2002_2007, D2009_2012 and D2013_2017 dummies) same as Table 3. Standard errors clustered by state in parentheses. * p<0.1, ** p<0.05, *** p<0.01.

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Table 7 – Focus on manual occupations

Dep var: Change in log employment (by category) per capita compared to 2008	Average hourly wage of manual workers	Manual workers with hourly wage > US median for manual workers	Manual workers with hourly wage < US median for manual workers	Manual workers with education > high school degree	Manual workers with high school degree or less
Green ARRA per capita (log) x D2005_2007	0.0052	0.0016	-0.0007	-0.0028	0.0024
	(0.0049)	(0.0042)	(0.0028)	(0.0046)	(0.0030)
Green ARRA per capita (log) x D2009_2012	-0.0029	0.0046	0.0088***	0.0117***	0.0038
	(0.0047)	(0.0032)	(0.0027)	(0.0043)	(0.0028)
Green ARRA per capita (log) x D2013_2017	0.0022	0.0099*	0.0123**	0.0121**	0.0096*
	(0.0055)	(0.0058)	(0.0049)	(0.0052)	(0.0053)
Jobs created, $1 million green ARRA:					
Pre-ARRA (2005-2007)	N/A	0.95	-0.35	-0.81	2.01
		(2.50)	(1.50)	(1.34)	(2.47)
Short-run (2009-2012)	N/A	2.34	4.01***	3.23***	2.61
		(1.63)	(1.25)	(1.19)	(1.91)
Long-run (2013-2017)	N/A	5.61*	6.01**	3.83**	7.12*
		(3.27)	(2.38)	(1.64)	(3.89)
Short-run - pre-ARRA	N/A	1.53	4.31**	4**	0.95
		(3.31)	(1.93)	(1.96)	(3.24)
Long-run - pre-ARRA	N/A	4.71	6.34**	4.71*	5.34
		(4.08)	(3.14)	(2.53)	(4.71)
R squared	0.3760	0.4825	0.4949	0.3488	0.5546
Observations	7631	7631	7631	7631	7631

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		(2.50)	(1.50)	(1.34)	(2.47)
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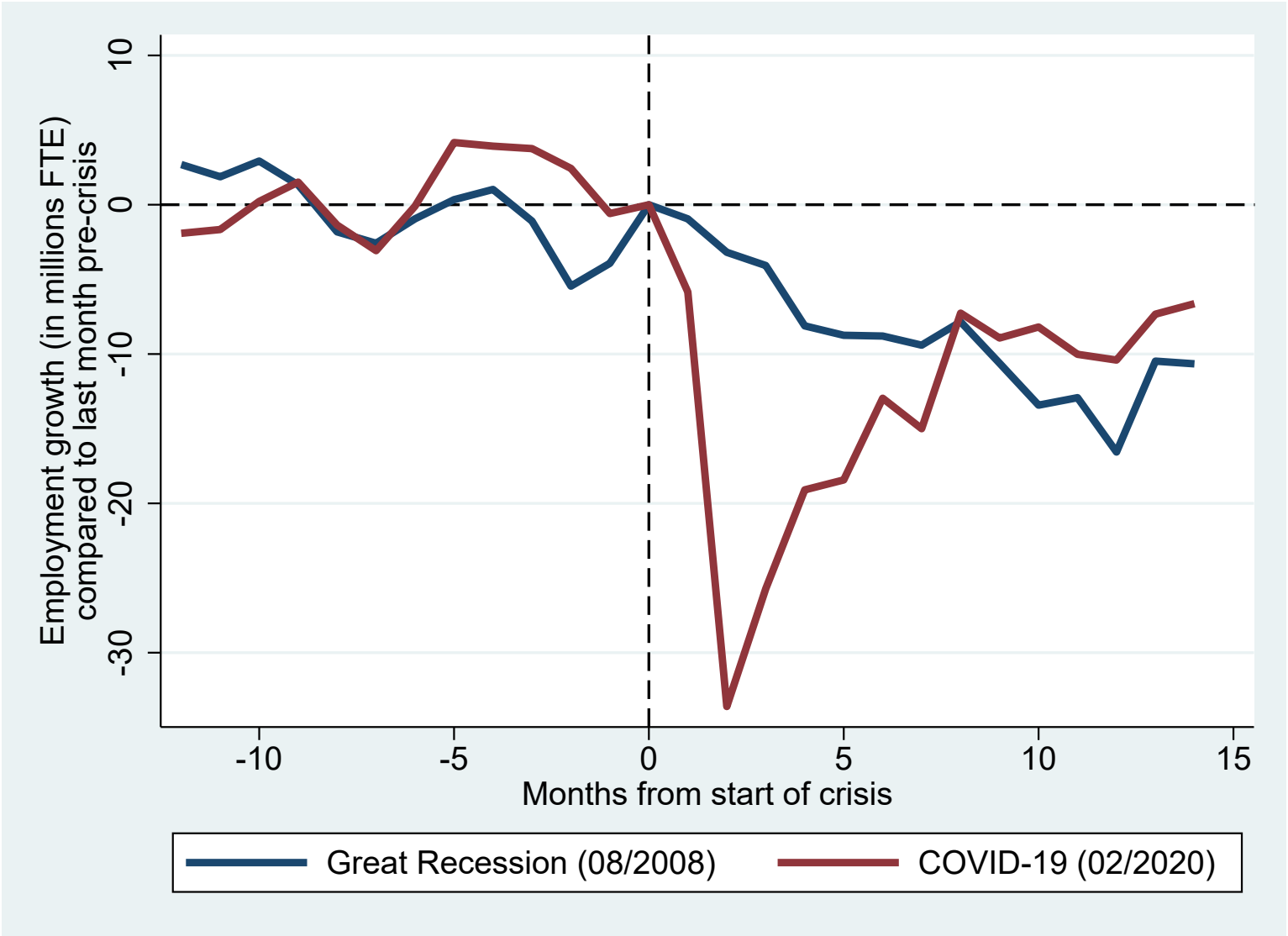
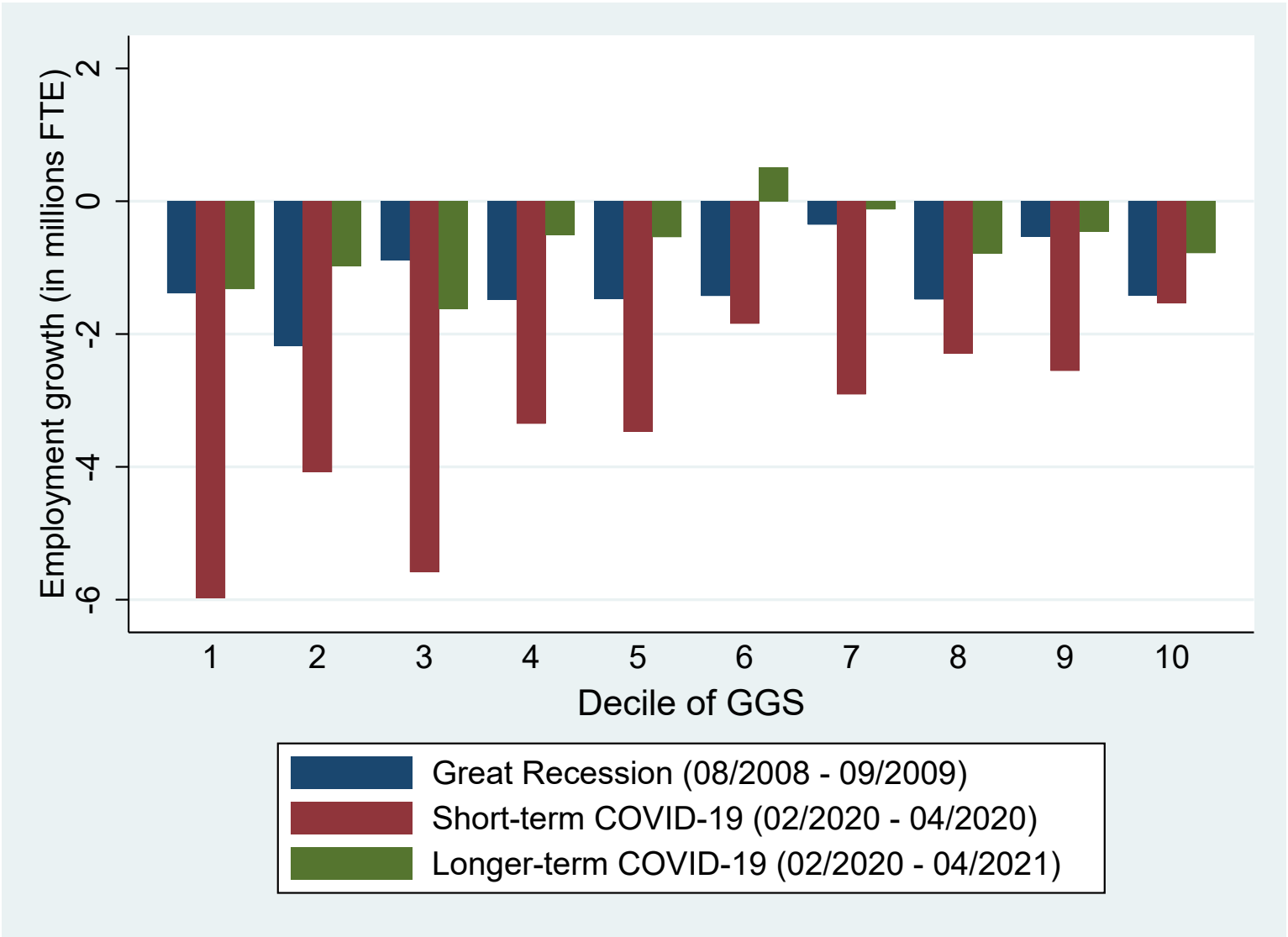
Great Recession vs Covid-19 crisis



Source: own elaboration on Current Population Survey monthly data.

Great Recession vs Covid-19 crisis: GGS content



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Skills and Covid-19 crisis

- **Reallocation costs** and **re-employability** are proportional to the **skill distance** between jobs (e.g.: Kambourov and Manovskii, 2009; Gathmann and Schonberg, 2010; Guvenen et al., 2020)
- Our results suggest **unskilled workers displaced** by **climate policies** in energy intensive sectors (Marin and Vona, 2019 JEEM) may find **new employment** opportunities in sectors related to the **green economy**, such as construction and waste management

Skills and Covid-19

Table 2 – Profiling of occupational groups

	% of total empl in 2017	Number of 6-digit SOC occupations	% of male employees	Age of employees (average)	Average hourly wage in 2017 (US$)	Locational GINI coefficient
Growing (2009-2017) green manual occupations	5.2%	18	92.6%	43	21.00	0.26
Growing (2009-2017) green manual occupations (weighted with greenness)	1.0%	18	90.3%	42	20.46	0.31
Benchmark: all non-green low-skilled occupations	59.2%	386	50.5%	39	16.97	0.33
Low-skilled occupations at risk because of Covid-19	34.2%	157	56.4%	37	15.57	0.31
Low-skilled occupations with highest RTI (top 10%)	9.8%	53	32.6%	38	14.14	0.32
Low-skilled occupations with highest computerization probability (top 10%)	7.9%	46	35.3%	38	14.99	0.32
Brown manual occupations	2.8%	79	79.3%	43	21.55	0.60

Description of variables: Locational GINI coefficient: average Locational Gini Coefficient (Gabe and Abel, 2012) across CZs based on ACS data for 2017, high values indicate high geographical concentration, low values indicate low geographical concentration (weights: occupational employment in 2017); Average hourly wage in 2017 (US$): average hourly wage from BLS-OES (weights: occupational employment in 2017); Age of employees (average): average age of employees from ACS 2017 (weights: occupational employment in 2017); % of male employees: average share of male employees from ACS 2017 (weights: occupational employment in 2017); % of total employment in 2017: share of total employment in group in 2017.

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Skills and Covid-19

Table 3 – Skills, Training and Educational requirements

Origin occupational group:	Training requirements (average months)	Education requirements (average)	Green General Skills (average score)	GGS distance wrt growing green manual occupations weighted by employment (2017) in origin occupation (median; Q1 and Q3 in parenthesis)	GGS 'Eng & Tech' distance wrt growing (2009-2017) green manual occupations (median; Q1 and Q3 in parenthesis)
Growing (2009-2017) green manual occupations	14.3	12.3	0.396	0.064 (0.044, 0.101)	0.055 (0.028, 0.085)
Growing (2009-2017) green manual occupations (weighted with greenness)	14.4	12.5	0.397	0.062 (0.043, 0.096)	0.051 (0.028, 0.088)
Benchmark: all non-green low-skilled occupations	6.8	12.1	0.271	0.130 (0.082, 0.185)	0.156 (0.083, 0.248)
Low-skilled occupations at risk because of Covid-19	7.3	11.7	0.284	0.114 (0.074, 0.154)	0.123 (0.074, 0.193)
Low-skilled occupations with highest RTI (top 10%)	5.3	11.9	0.209	0.158 (0.113, 0.234)	0.189 (0.112, 0.348)
Low-skilled occupations with highest computerization probability (top 10%)	4.4	11.9	0.221	0.152 (0.117, 0.208)	0.186 (0.116, 0.273)
Brown manual occupations	11.9	12.1	0.337	0.063 (0.042, 0.097)	0.062 (0.036, 0.114)

Description of variables: Training requirements (average months): average training requirement (in months) based on O*NET (weights: occupational employment in 2017); Education requirements (average years): average education requirement (in years) based on O*NET (weights: occupational employment in 2017); Green General Skills (average score): average score of the four Green General Skills as defined in Vona et al. (2018) based on O*NET data (weights: occupational employment in 2017); GGS (Green General Skills) distance is based on Gathmann and Schönberg (2010) and is defined in equation 1 (median and quartiles are weighted using occupational employment in 2017).

Skills and Covid-19

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Concluding remarks

- 2009 green ARRA investments **created jobs**, but more **slowly** than other ARRA investments ⇒ **skills** matter
- Future research should consider explicitly whether job **training** can help
- A **green stimulus** can **reshape the economy**, but **less clearly** be used to **restart** the economy
- **Green investments will not help** those most **vulnerable** to unemployment in the **pandemic**

THANK YOU FOR YOUR ATTENTION

giovanni.marin@uniurb.it

Figure: Flow of ARRA spending (source: Wilson, 2012 AEJ-EP)

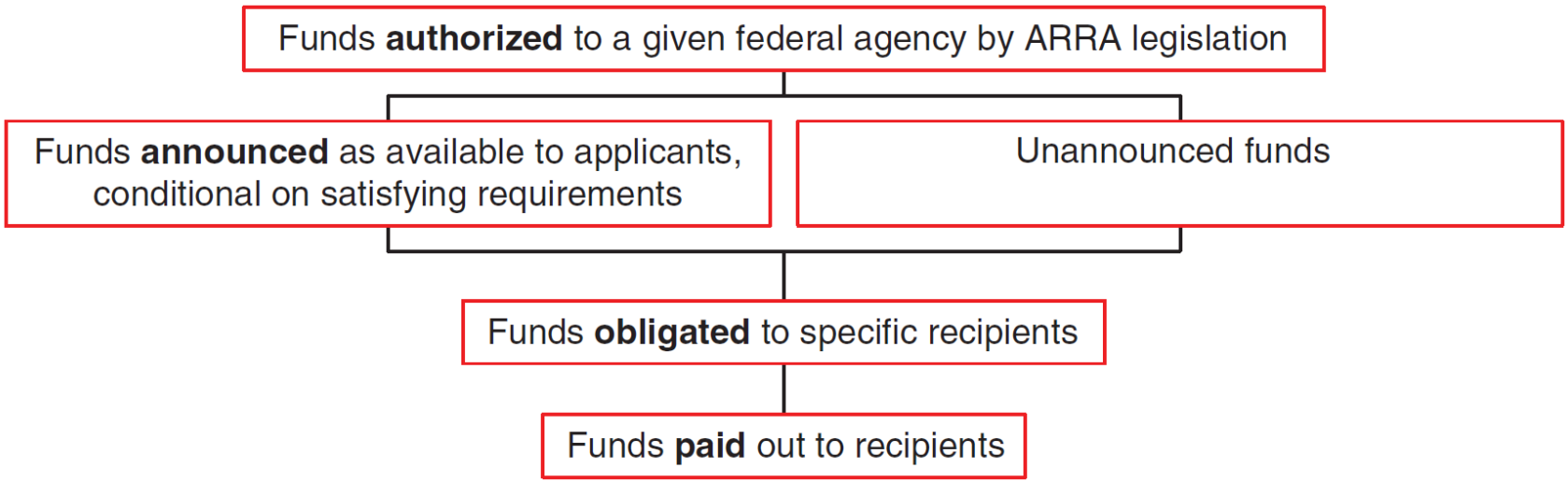

Figure: Skill content of green jobs

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Do green jobs differ from non-green jobs in terms of skills and human capital?

Davide Consoli [a,*], Giovanni Marin [b,c,d], Alberto Marzucchi [e,c,f], Francesco Vona [d,h]

Table 6
Profiling of green occupations: education, experience and training.

	(1) log(years of educ)	(2) log(years of exp)	(3) log(years of train)
Green emerging	0.0205	−0.0515	0.168*
	(0.0221)	(0.124)	(0.0998)
Green enhanced skills	0.0191**	0.357***	0.341***
	(0.00861)	(0.113)	(0.129)
Joint sign. green occ dummies (F)	2.609*	5.982***	3.815**
N	465	465	465

OLS estimates weighted by employment share. Robust standard errors in parenthesis.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.
SOC 3-digit dummies included. Occupations in SOC 3-digit categories with no green occupation have been excluded.

Table 5
Profiling of green occupations: skill measures.

	(1) NR analytical	(2) NR interactive	(3) R cognitive	(4) R manual	(5) NR manual	(6) RTI index
Green emerging	0.0293	−0.00737	−0.0320*	−0.0152	−0.00291	−0.0692
	(0.0187)	(0.0205)	(0.0192)	(0.0149)	(0.0364)	(0.0476)
Green enhanced skills	0.0297**	0.00404	−0.0198*	−0.00508	0.0152	−0.0583**
	(0.0130)	(0.0145)	(0.0108)	(0.0155)	(0.0162)	(0.0269)
Joint sign. green occ dummies (F)	3.309**	0.120	2.489*	0.519	0.456	2.996*
N	465	465	465	465	465	465

OLS estimates weighted by employment share. Robust standard errors in parenthesis.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.
SOC 3-digit dummies included. Occupations in SOC 3-digit categories with no green occupation have been excluded.

Green Jobs: an ambiguous concept

- Jobs in **green industries** (products or processes)
  - **Eurostat** and **BLS** approach ⇒ Environmental Goods and Services Sector and Green Goods and Service Sectors
  - The **industry** is **green**, the jobs (e.g. occupations) not necessarily
  - Even the **definition** of environmental/green **sectors** is **not clear** (little environmental pressures? Positive contribution to resource saving and improved environmental quality?)
- **Decent jobs** linked to the green economy (ILO)
- Green **occupations**
  - The unit of analysis is the **occupation**, **not** the **sector**
  - Occupations performing **green tasks** or affected by the green economy, employed in any industry (O*NET, Dierdroff et al., 2009)
  - Occupations **identified** starting from the **existing** (heterogeneous) **literature**

The *Green Economy Initiative* by O*NET

Dierdorff et al (2009) *Greening of the World of Work: Implications for O*NET-SOC and New and Emerging Occupations*

- **Three** different **categories** of green occupations:
  - 'Increased **demand**' occupations (with no specific 'green tasks') ⇒ their **demand** is likely to **increase** thanks to the '**green economy**' with **no expected change** in the **skill** content of these occupations
  - '**Enhanced skills**' occupations ⇒ the '**green economy**' is likely to **affect** the **skill** and task contents of these **existing** occupations
  - '**New** and emerging' occupations ⇒ the '**green economy**' requires **new occupations** that did not exist before
- After identifying these occupations, recent **updates** of the **O*NET** catalogue have assessed the **green specific tasks** of '**Enhanced skills**' and '**New** and emerging' occupations

Greenness of occupations

- The **distinction** between **green** and **non-green** occupations is not dichotomous
- For **some** green occupation, **green specific tasks** are just **marginal** activities while for **other** occupations they represent the **core** of their activities
- We use our measure of '**greenness**' $\frac{\#green\_specific\_tasks}{\#total\_specific\_tasks}$ as a **proxy** of the **relative importance** of green tasks for an occupation

Table: Examples of green occupations by level of greenness

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

General Green Skills - GGS (Vona et al, 2018)

	Engineering & Technical
2C3b	Engineering and Technology
2C3c	Design
2C3d	Building and Construction
2C3e	Mechanical
4A3b2	Drafting, Laying Out, and Specifying Technical Devices, Parts, and Equipment
	Science
2C4b	Physics
2C4d	Biology
	Operation Management
2B4g	Systems Analysis
2B4h	Systems Evaluation
4A2b3	Updating and Using Relevant Knowledge
4A4b6	Provide Consultation and Advice to Others
	Monitoring
2C8b	Law and Government
4A2a3	Evaluating Information to Determine Compliance with Standards

Selection of Green General Skills (Vona et al., 2018)

- **O*NET** (Occupational Information Network) provides a detailed **catalogue of general skills and tasks** (about 400 items) with **importance scores** for a detailed list of **occupations** (more than 900)
- Based on a **data-driven** approach we **select** those general skills that have **systematically** and significantly greater **importance** scores in occupations with high level of '**greenness**'

$$Task\_Imp_k^I = \alpha + \beta^I \times Greenness_k + D_k^{SOC\_3digit} + \varepsilon_k$$

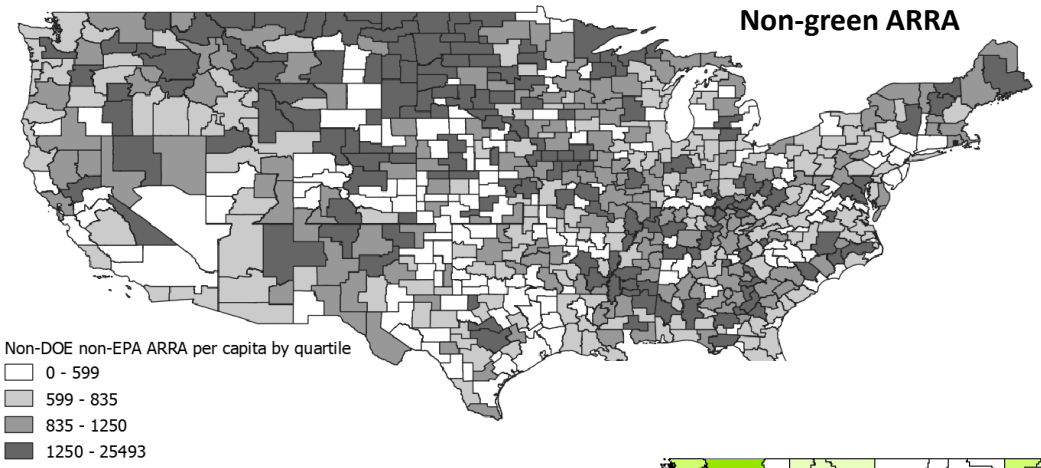
- A general skill is identified as a **Green General Skill** (GGS) if the coefficient β^I is **positive** and statistically **significant** (1 percent)
- The selected **GGS** are then **grouped together** with the support of a **principal component analysis**

15-1199.05 - Geographic Information Systems Technicians

- **Description:**
  - *Assist scientists, technologists, or related professionals in building, maintaining, modifying, or using geographic information systems (GIS) databases. May also perform some custom application development or provide user support.*
- **Green specific tasks (5):**
  - 19585 - Analyze Geographic Information Systems (GIS) data for use in urban planning applications that promote better land use or reduce environmental impacts of development.
  - 19588 - Confer with biologists or other researchers in the use of Geographic Information Systems (GIS) data to define wildlife areas or corridors for land use planning.
- **Non-green specific tasks (14):**
  - 16088 - Select cartographic elements needed for effective presentation of information.
  - 16089 - Transfer or rescale information from original photographs onto maps or other photographs.
- **Greenness:** $\frac{\#green\_specific\_tasks}{\#total\_specific\_tasks} \Rightarrow$ **5/19=0.26**

What IS NOT green skill? A selection...

2A1b	Active Listening
2A1d	Speaking
2A1f	Science
2A2b	Active Learning
2A2d	Monitoring
2B1b	Coordination
2B1d	Negotiation
2B1f	Service Orientation
2B3a	Operations Analysis
2B3c	Equipment Selection
2B3e	Programming
2B3j	Equipment Maintenance
2B3l	Repairing
2B4e	Judgment and Decision Making
2B5b	Management of Financial Resources
2B5d	Management of Personnel Resources
2C1b	Clerical
2C1e	Customer and Personal Service
2C2a	Production and Processing
2C3a	Computers and Electronics
2C4e	Psychology
2C5a	Medicine and Dentistry
2C6	Education and Training
2C7b	Foreign Language
2C7e	Philosophy and Theology
2C9a	Telecommunications
4A1b1	Identifying Objects, Actions, and Events
4A2b1	Making Decisions and Solving Problems
4A2b6	Organizing, Planning, and Prioritizing Work
4A3a3	Controlling Machines and Processes
4A3b5	Repairing and Maintaining Electronic Equipment
4A4a4	Establishing and Maintaining Interpersonal Relationships
4A4a7	Resolving Conflicts and Negotiating with Others
4A4b3	Training and Teaching Others
4A4b5	Coaching and Developing Others
4A4c2	Staffing Organizational Units


Non-green ARRA
Non-DOE non-EPA ARRA per capita by quartile
0 - 599
599 - 835
835 - 1250
1250 - 25493

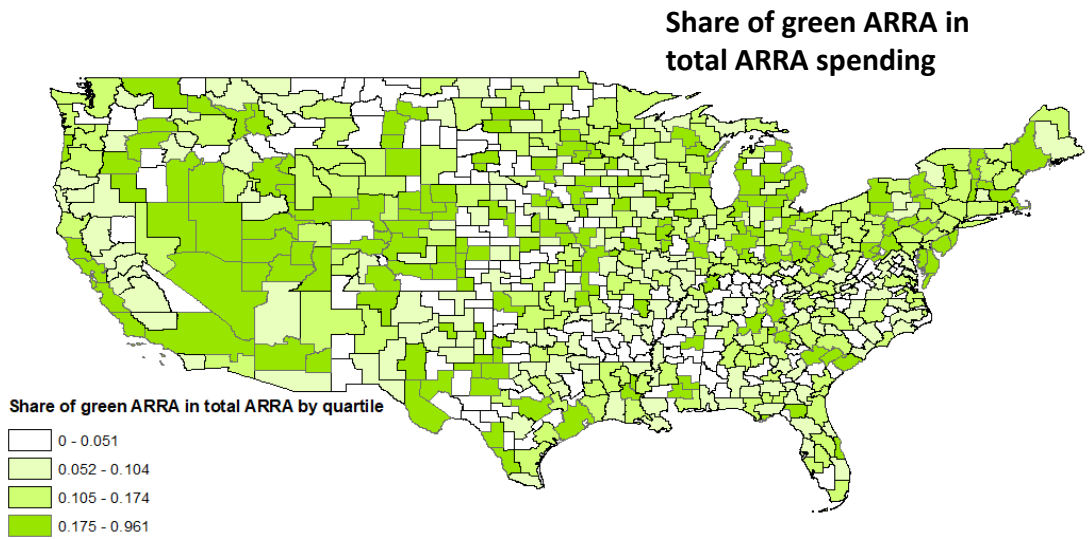
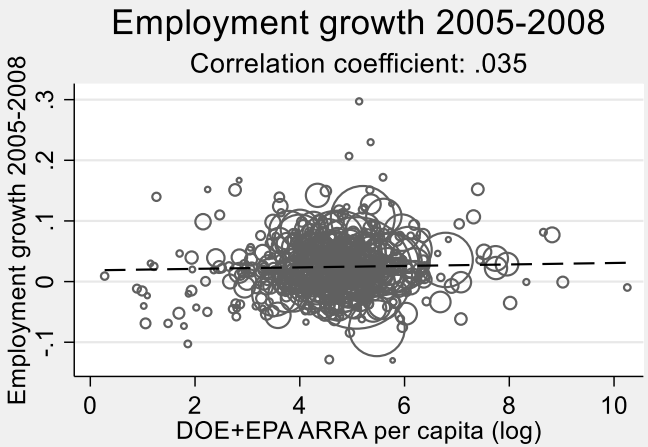
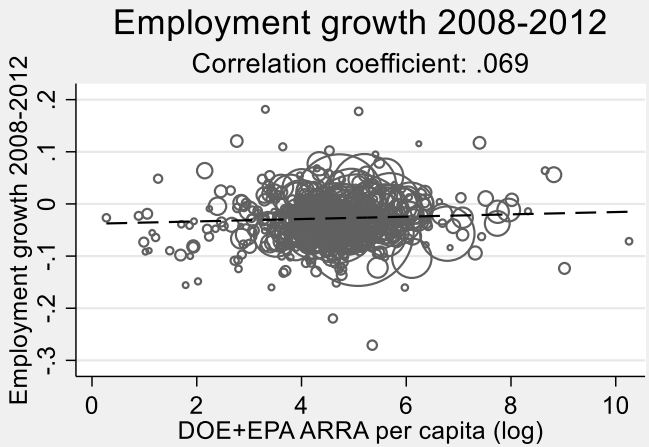

Share of green ARRA in total ARRA spending
Share of green ARRA in total ARRA by quartile
0 - 0.051
0.052 - 0.104
0.105 - 0.174
0.175 - 0.961

Figure: Green ARRA pc vs employment growth





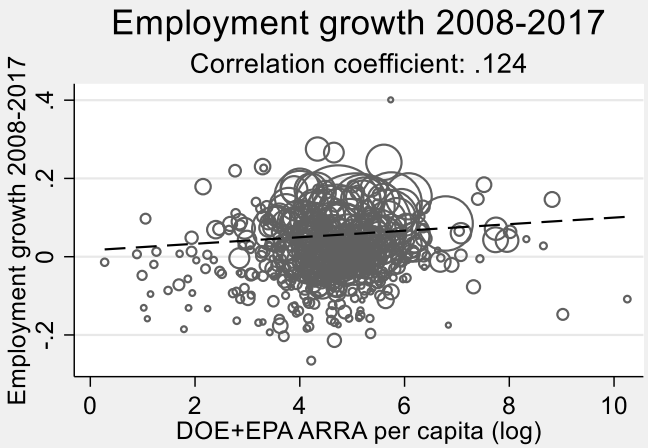


Figure: Non-green ARRA pc vs employment growth