Comments and Discussion

COMMENT BY

GABRIEL CHODOROW-REICH Popp, Vona, Marin, and Chen have written an ambitious paper on an important topic. Advocates of a Green New Deal sometimes claim a substantial macroeconomic dividend from the investments required to transition the US economy away from fossil fuels. The authors provide an empirical assessment of this possibility, taking account of both the workers likely to be displaced in such a transition and the evidence from the clean energy investments contained in the 2009 American Recovery and Reinvestment Act (ARRA). They arrive at a more nuanced conclusion, yet retain optimism for the potential for clean energy investments to absorb displaced workers.

I will divide my comment into three parts. The first concerns the relationship among temporary stimulus, permanent job creation, and permanent structural transformation and what one can learn from the ARRA for the paper's ultimate question. The second articulates my view of the difficult econometric and measurement challenge the authors face in studying the green aspects of the ARRA. The third broadens to consider lessons from other structural transformations.

TEMPORARY STIMULUS VERSUS PERMANENT STRUCTURAL TRANSFORMATION

My first point concerns the relationship among temporary stimulus, permanent job creation, and permanent structural transformation. There are two main reasons why policymakers might consider the green transformation as part of macroeconomic policy. The first is an opportunity. Governments can pull forward green investments to periods when resources are otherwise idle, namely, a recession. This is properly termed fiscal stimulus. According to standard economic theory, by raising the aggregate demand for labor, temporary fiscal stimulus can increase total employment temporarily while resources remain idle. Targeted investments can lead to

Table 1. DOE and EPA Programs

Agency	*Program*	*Appropriation ($ billions)*	*Outlays as of 2013:Q4 ($ billions)*
DOE	Energy efficiency and renewable energy	16.80	15.50
EPA	State and tribal assistance grants	6.34	6.21
DOE	Defense environmental cleanup	5.13	5.11
DOE	Electricity delivery and energy reliability	4.50	3.97
DOE	Fossil Energy Research and Development	3.40	1.22
DOE	Western Area Power Administration Borrowing Authority	3.25	0.22
DOE	Bonneville Power Administration fund	3.25	1.36
DOE	Title 17 Incentives for Innovative Technologies loan guarantee	2.50	1.33
DOE	Science	1.60	1.59
EPA	Hazardous Substances Superfund	0.60	0.62
DOE	Non-defense environmental cleanup	0.48	0.44
DOE	Energy Transformation Acceleration Fund	0.40	0.35
DOE	Uranium Enrichment Decontamination and Decommissioning Fund	0.39	0.39
EPA	Leaking Underground Storage Tank Trust Fund	0.20	0.19
EPA	Environmental Program and Management	0.06	0.08
DOE	Advanced Technology Vehicles Manufacturing Loan Program	0.01	0.01
DOE	Construction, rehabilitation, operation, and maintenance, Western Area Power Administration	0.01	0.01

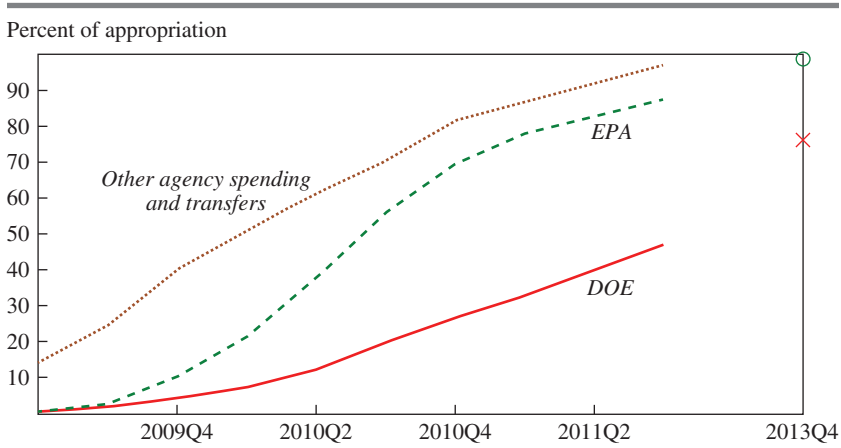
Sources: Agency FAR reports and author's calculations.

permanent reallocation of employment toward green industries or to certain geographic areas but do not permanently increase aggregate labor demand.

The second reason policymakers might think of a green transformation in macroeconomic terms stems from a problem. Many workers currently employed in industries that emit greenhouse gas (GHG) eventually will have to find some other way to make a living. Because of frictions involved in finding new employment or gaining new skills, policy may want to provide support for the losers in the industrial reshuffling. Temporary stimulus cannot satisfy this objective, and measures to address it should not be conflated with temporary stimulus. Instead, such measures involve sustained demand-side support such as investment incentives for new businesses to locate in heavily impacted areas, supply-side interventions such as worker retraining, or simply financial support for displaced workers such as wage insurance or pension payments.

What type of spending did the ARRA contain? Table 1 lists the Department of Energy (DOE) and Environmental Protection Agency (EPA)

Figure 1. Time Path of ARRA Spending by Agency



Sources: Agency FAR reports and author's calculations.
Note: Spending in 2011:Q4–2013:Q3 omitted for lack of data.

spending programs along with their appropriation and total outlays through 2013:Q4. Most of these programs fall under the umbrella of temporary stimulus, such as financing energy efficiency retrofits or investments in the smart grid. Almost all of the spending had concluded by the end of 2013.[1]

Figure 1 shows the time path of the spend-out of various components of the ARRA, expressed as a share of their appropriation.[2] The dotted line shows the path of all non-energy outlays. Most non-energy outlays had concluded by the end of 2010. The dashed line shows EPA spending, which accounts for $7.2 billion of the combined (EPA and DOE) $49 billion appropriation. EPA spending ramps up more slowly than total ARRA but at a pace similar to most of the non-transfer components, and about three-quarters had been outlaid by the end of 2010. In contrast, the Department of Energy had outlaid only about one-quarter of its total appropriation by the end of 2010. The X shows the total share in 2013:Q4. DOE outlays

1. Much of the difference between outlays as of 2013:Q4 and the initial appropriation involves programs that never spent out their full appropriation. Such programs include a combined $6.5 billion in borrowing authority for the Bonneville Power Administration and Western Area Power Administration, of which only $1.58 billion had been used as of 2013:Q4, and the Title 17 innovative technologies loan guarantee program, which had a $2.5 billion appropriation but recorded charges of only $1.3 billion as of 2013:Q4.

2. The figure omits spending in 2011:Q4–2013:Q3 as I do not have data for those quarters and the original repositories of the data are no longer available.

were larger in 2011–2012 than they were in 2009–2010. Nonetheless, most spending had been completed by the end of 2013.

This discussion helps to frame the paper's headline finding of delayed but possibly permanent employment effects from the clean energy provisions of the ARRA. The slow spend-out of DOE programs explains why they had little impact in 2009–2010. Even so, the economy remained demand-constrained in 2011 and 2012, as evidenced, for example, by the Federal Reserve's target federal funds rate remaining close to zero until the end of 2015. Thus, it seems plausible that clean energy investments in that period absorbed slack resources and resulted in higher total employment. It would be more surprising for such spending to continue to produce meaningfully higher economy-wide employment in 2019, well after all of the spending took place and when the economy was at or near full employment. For this reason, I am inclined to treat the paper's wide range of possible estimates of long-run employment effects as providing little reason to move my prior that such effects would be small. Of course, it could be the case that certain geographic areas continued to benefit because of earlier investments in business capital, which highlights the distinction between local and national multipliers.[3]

ECONOMETRIC AND MEASUREMENT CHALLENGE My second point concerns the econometric challenge of estimating the employment effects of the ARRA's clean energy provisions. As discussed carefully in the paper, ARRA spending on green programs was likely targeted toward areas with existing green infrastructure or potential. For example, research and development grants went to places with scientific laboratories already working on energy matters and wind turbines were built in places with high wind potential.

The nonrandom allocation of funds raises the possibility of omitted variable bias. The generic concern is that areas with existing green infrastructure share other characteristics that made them subject to correlated shocks or have similar loadings on aggregate shocks, such as less exposure to the 2008 recession. For example, maybe these places also had a less dramatic house price cycle. This is a failure of the law of large numbers (Borusyak, Hull, and Jaravel 2022)—with only one ARRA to study, it is

3. In theory, an increase in investment in an area could permanently pull in workers from other areas, making the local employment effects larger than the national effects (Chodorow-Reich 2019). Even so, the geographic concentration of fossil fuel–related jobs suggests that the local multiplier concept analyzed in the paper may be especially informative, since the objective is in part to reduce the negative effect on highly impacted local communities.

possible that other forces happened to have an impact in these particular areas at the same time. Indeed, the presence of pre-trends indicates *something* about these areas that made them correlated even before they ever received ARRA funds.

The specific concern is that the economy was becoming greener even absent the ARRA, resulting in faster growth in areas with existing green infrastructure or potential. Pre-trends are an imperfect diagnostic for this concern, since secular greening may have been more important post-2008 than before. Importantly, this issue is quite different from the typical omitted variable problem with the ARRA or other fiscal stimulus, which is that funds were targeted to harder hit areas, biasing down the estimated jobs effect. Here the direction is the opposite—funds may have gone to areas already greening, and the additional green jobs were due to the secular transition rather than the ARRA per se.

An example can illustrate. There were large ARRA grants and tax credits to support wind and solar development and installation. These provisions obviously were most likely to benefit areas with lots of wind and sun. In many cases, the physical environment provides excellent variation for identifying causal effects—think, for example, of papers using rainfall shocks as an excluded instrument for income or physical land constraints as an excluded instrument for housing supply. But in the context of the ARRA, a problem arises if wind and solar were becoming more competitive anyway due to the rapidly declining cost of imported solar panels and wind turbines, because the declining cost would generate wind and solar investment in places with high wind and sun even absent the ARRA. This problem explains why the authors choose to control for wind and sun potential rather than exploiting it as a physical determinant of green ARRA allocation. Put this way, however, it is immediately clear that the same concern applies to any shift-share design.[4]

Taking stock, one can understand why the econometric specification contains many controls, yet this makes it difficult to assess what determines the remaining variation in green ARRA allocation. The paper emphasizes the absence of pre-trends in the results for green and occupational employment in arguing for a cleaner interpretation of these results, but ultimately

4. The issue is a bit more subtle in the interaction specification but does not disappear. In particular, if green suitability is measured with error, then the interaction coefficient may also pick up the tendency for funds to go to areas expected to expand based on unobservables to the econometrician.

Table 2. Measuring Green Jobs

	%
Population-weighted median green share (GS)	3.05
Bootstrap-weighted median SD	0.16
Weighted median coefficient of variation	5.24

Sources: 2013 American Community Survey and author's calculations.

macroeconomic policy must care about total employment, not sectoral employment. And the stubborn endurance of pre-trends in the results for total employment suggests there still may be common shocks or trends affecting these areas.

A final challenge to estimating the impact on green jobs arises even with a perfect research design. The paper defines greenness by occupation rather than industry. Measuring green jobs therefore requires survey data with occupation codes, which the paper takes from the American Community Survey (ACS). But green jobs are a small share of the total economy, about 3 percent of total hours worked. Dividing the ACS into commuting zones and then restricting to the 3 percent of hours worked in green occupations results in pretty small sample sizes of green workers. Table 2 reports the variation in green share due only to sampling variability. To compute this table, I drew fifty bootstrap samples of individuals by public use microdata area (PUMA, i.e., a stratified bootstrap sample following the ACS sample design) in the 2013 ACS, computed the green share following the paper's occupational categorization, and aggregated the bootstrap samples up to the commuting zone level. The weighted median coefficient of variation across commuting zones is 5.24 percent. This implies a standard deviation of roughly $100 \times \sqrt{2 \times 0.0524^2} = 7$ percentage points in the growth rate of green jobs in the typical commuting zone due only to sampling variability. Of course, the standard errors already reflect this sampling variability; my point is simply to highlight the difficulty in this setting of generating precise multiplier estimates for green jobs.

LESSONS FROM OTHER STRUCTURAL TRANSFORMATIONS My final point is in regard to the broader aspects of the clean energy transformation. The first part of the paper provides a very nice analysis of the skill gap between GHG-emitting industries and green industries, motivated by lessons from earlier episodes of structural transformation. This important analysis should somewhat reassure policymakers, though I will note that the general equilibrium reallocation of workers need not necessarily involve the same people who leave GHG-emitting industries to then find work in green industries.

What we know about the secular decline of major industrial sectors offers little overall encouragement. Displaced workers often do not quickly transition to new jobs and instead suffer harmful long-term consequences, as illustrated for example by Autor, Dorn, and Hanson (2021). Job retraining may be part of the solution (Hyman 2018) but is particularly difficult for older, less educated workers. Other proposals such as wage insurance seem worth considering but go considerably beyond the scope of my remarks here. Instead, I will reemphasize my first point about the distinction between temporary stimulus and long-term solutions. Some of the proposed investments discussed in the paper, such as plugging orphan oil wells or cleaning abandoned mines, might qualify as temporary stimulus if the US economy were to enter a demand-driven recession, and surely these projects are worthwhile for their environmental benefits, but these sorts of onetime investments or cleanup projects cannot provide permanent alternative work for workers displaced by the clean energy transformation.

On the other hand, a strong macroeconomy is conducive to sectoral transformation. Johannes Wieland and I refer to this as macroeconomic policy "greasing the wheels" of reallocation by accommodating higher inflation (Chodorow-Reich and Wieland 2020). Guerrieri and others (2021) explicitly develop this point. With downward wage rigidity binding in a recession, wages cannot fall in shrinking industries. Without this price signal for workers to reallocate, they instead remain looking for work in declining industries, slowing down the transformation and exacerbating unemployment. This gives a rationale for wanting a hot economy to facilitate a transition and even to tolerate possibly above-trend inflation.

CONCLUSION This is a thought-provoking paper on an important and challenging topic. Overall, I find myself somewhat less optimistic than the paper about the labor market challenges of the green transition, although also more optimistic than before I read it.

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COMMENT BY

VALERIE A. RAMEY This very interesting paper by David Popp and colleagues offers a comprehensive analysis of the employment effects of the transition from fossil fuels to green energy. A particular focus of the paper is assessing the extent to which green fiscal stimuli can mitigate the negative employment effects on fossil fuel workers. This question is important because government policies designed to convert energy production from fossil fuels to green energy may face political opposition from the potential losers.

The paper consists of four parts. The first part surveys the literature on the effects of environmental policies on employment, with attention to heterogeneity in skills and geography. The second part presents evidence comparing the skill requirements of green jobs with the skill endowment of workers in fossil fuel industries. The depth and breadth of the analysis of the various types of heterogeneity make these two parts a valuable resource for academics and policymakers. The third part analyzes the employment effects of the green spending in the 2009 American Recovery and Reinvestment Act (ARRA) at the commuting zone level. This part of the analysis is an ambitious undertaking since features of the data present multiple challenges to obtaining definitive answers. Finally, the fourth part discusses the policy implications of the findings of the paper.

Most of my comments concern the interpretation of the ARRA estimates. First, I discuss what the authors' local estimates imply about aggregate effects and what macroeconomic theory predicts about the aggregate effects of infrastructure spending. Second, I summarize the authors' green ARRA employment findings and compare them to the estimated effects of the highway spending components of the ARRA. Third, I discuss green incentives that were not included in the authors' analysis, specifically the effects of tax credits for rooftop solar, and how the effects of these incentives may confound the authors' estimates. I also discuss advantages that rooftop solar has over some alternatives. Finally, I return to the authors' motivating question