COMMENT BY

VALERIE A. RAMEY This paper by David Popp and co-authors is an impressive, expansive paper analyzing 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 of the green transition on fossil-fuel workers. This question is important because government policies designed to convert energy production from fossil fuels to green energy may face 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 hetereogeneity 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. These first two parts are a very useful contribution to the literature, since the depth and breadth of the analysis of the various types of heterogeneity are a useful resource for academics and policy makers. I learned a great deal from these sections. The third part analyzes the employment effects of the green spending in the 2009 American Recovery and Reinvestment Act (ARRRA) at the commuting-zone level. This is a very ambitious undertaking, particularly with the challenges the authors face in obtaining definitive answers. Finally, the fourth part discusses the policy implications of the findings of the paper.

My discussion is organized as follows. First, I put the authors' estimates in context by discussing the predictions of theory concerning how local effects relate to aggregate effects and what kinds of aggregate effects infrastructure spending should be expected to have. Second, I summarize the authors' green ARRA employment findings and compare them to the estimated effects of the highway spending parts 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 those incentives may confound the authors' estimates. I also discuss advantages that rooftop solar has over some alternatives. Finally, I consider the broader impacts of the green transition on fossil fuel communities. I refer specifically to the example of the mining towns in Asturias, Spain.

WHAT THEORY PREDICTS ABOUT THE EFFECTS OF INFRASTRUCTURE SPENDING The authors present estimates of the employment effects of the green spending in the ARRA using variations across commuting zones. They consider the effects at a variety of

horizons and find small effects in the first few years but then apparently permanent positive effects on job creation. Before using these estimates to guide policy, it is important to put these effects in context by considering some recent lessons from the recent fiscal literature and other literatures that use local data to answer macro questions.

The first lesson from the literature is that local effects, which the authors estimate, are not the same as aggregate effects. Because the panel data estimation uses year-fixed effects, all aggregate effects are removed. Thus, the estimates of employment effects are *relative* effects that answer the following question: if Commuting Zone A receives $1 more than the other commuting zones, how much does employment change in Commuting Zone A relative to the average? This estimate is different from the aggregate effect in several ways. First, it does not incorporate the added general equilibrium effects due to tax or deficit financing. Second, it may be smaller or larger than the aggregate estimate: it may be smaller if there are positive spillovers across commuting zones, but it may be larger if there are "business stealing" effects across commuting zones.

A second insight that comes out of the infrastructure literature is the implication of time-to-spend and time-to-build delays that are inherent to infrastructure projects. Figure 1 shows the cumulative percent of total ARRA infrastructure appropriations that were spent each year. Despite the emphasis on "shovel-ready projects," only 10 percent of appropriations were spent by Summer 2009 and under 60 percent had been spent by the following summer. As I now demonstrate, if there were also delays in green infrastructure spending, then the minimal short run effects estimated by the authors can be explained.

As Leeper et al. (2010) and others have argued, these delays severely reduce the short-run stimulus effects of infrastructure investment. In Ramey (forthcoming), I show that even in a medium-scale New Keynesian model, calibrated to give high multipliers for government consumption spending, infrastructure spending with time-to-spend and time-to-build delays offers little short-run stimulus. To illustrate the effects, Figure 2 shows the simulations from a version of the New Keynesian model used in my work. The graphs show the effects of either a shock to government consumption or government infrastructure investment appropriations. In both cases, the appropriations process is assumed to be serially correlated so that the initial bump to appropriations is followed by smaller additions to appropriations until they return to zero after about three years. In the case of government consumption spending, appropriations translate immediately into government spending. However, in the case of government infrastructure

spending, there are both time-to-spend and time-to-build delays. In particular, a one-unit rise in appropriations is spread out equally over the next eight quarters. In addition, infrastructure does not become productive until eight quarters after the beginning of construction.

Figure 2 shows the paths of government spending, output, employment, and private investment for each of the two experiments. These graphs show that a shock to government consumption appropriations equal to one percent of GDP leads output to rise by more than 1.3 percent, implying an impact multiplier above 1.3. Employment rises 1.7 percent relative to its steady state. Private investment builds up slowly because of the assumption of adjustment costs to investment. Overall, the rise in government consumption has significant short-run stimulus effects in this New Keynesian model. As discussed in Ramey (forthcoming), the three most important features of the model for the short-run stimulus effects are (i) adjustment costs on private investment (which prevent the standard crowding out); (ii) the presence of "hand-to-mouth" households who always consume 100 percent of their income; and (iii) employment is mostly determined by labor demand and not labor supply.

The effects are very different for infrastructure spending because of the time-to-spend and time-to-build lags. Because of the spending delays, output and employment do not rise on impact and in fact fall slightly. Without the government spending, firms do not demand more labor, so the hand-to-mouth households do not experience rises in income and hence do not consume more. Once spending ramps up, there is a slow rise in output and employment. Private investment falls in the short run and then rises more in the intermediate run. The first lesson from these simulations is that time-to-spend and time-to-build delays prevent government infrastructure spending from acting as a short-run stimulus.

The second lesson from the simulations is the theoretical prediction about the long-run effects on employment. As Figure 2 shows, output is predicted to remain above its steady state out through ten years (forty quarters) because of the higher level of public capital. However, employment returns to its steady state after four years. Both a standard neoclassical model and a New Keynesian model predict that a relatively transitory rise in either government consumption or government investment should have no noticeable effect on long-run employment. This result should be kept in mind when considering the plausibility of the Popp et al. estimates suggesting more permanent employment effects.

SUMMARY OF POPP ET AL. ESTIMATES WITH A COMPARISON TO THE EFFECTS OF THE ARRA HIGHWAY CONSTRUCTION SPENDING Popp and co-authors show (in their Figure 2) the estimates of the relative employment effects of the green spending in the ARRA based on their commuting zone data. Their estimates imply about 10 jobs created per $1 million in the first year of the ARRA in 2009, gradually rising to a plateau of about 25 jobs per $1million by 2017. They conclude that the ARRA green spending, which was temporary, may have led to permanent job creation.

This pattern of slowly rising effects of jobs created at longer horizon contrasts with results for highway spending. For example, Garin (2019) studies the job creation effects of the road and highway spending part of the ARRA at the county level. Focusing first on construction employment, he finds that the spending raises highway construction employment little the first year (2009), but then creates a peak of 2 jobs per $1 million in 2010, then slowly tapers back to 0. When he studies total payrolls (in dollars), he finds no effect the first several years, then a rising effect that peaks in 2013 before declining again. Thus, Popp and co-authors' finding of an ever-rising job creation rate contrasts with Garin's results for the highway construction parts of the ARRA. One possible source of the permanent estimates in the Popp et al. analysis is the presence of pre-trends. As Popp et al. highlight, and is evident in their Figure 2, it appears that there are significant pre-trends. Thus, the estimates of the long-run effects could reflect that the commuting zones that received more green energy spending had higher trend rate of employment growth irrespective of the ARRA green spending.

In contrast, Popp et al.'s estimates of employment effects by category are on firmer ground, since there are no significant pre-trends. Employment in manual occupations, green jobs, and construction jobs share a similar pattern: little or no effect for the first three years after the initial spending but then rising to a higher plateau from around 2012 through 2017. These higher intermediate-run effects are quite different from the more transitory effects Garin finds for highway spending.

These more persistent effects on employment categories at the commuting zone level found by Popp and co-authors are not necessarily at odds with the dynamic general equilibrium analysis shown above. The dynamic general equilibrium analysis shows that the effects on *aggregate* employment should last only during the transition. That does not mean, however, that there cannot be permanent reallocations of employment across job categories or geographic levels. The next

section, however, suggests that an important additional green program may be confounding the effects.

SOLAR TAX INCENTIVES: POSSIBLE CONFOUNDING EFFECTS AND JOB CREATION POTENTIAL The authors focus on the green spending elements of the ARRA, but do not consider tax incentives for green energy since they are beyond the scope of the paper. I believe that these additional incentives cannot be ignored because they are likely to confound the estimates of the effects of the spending program.

Residential and commercial investment federal tax credits for rooftop solar were adopted in the mid-2000s and subsequent legislation has extended them multiple times. The tax credit was 30 percent of the installation cost of rooftop solar until recently, when it was reduced to 26 percent. Thus, the tax incentive regime completely overlaps the period of analysis by Popp and co-authors. Moreover, the price of photovoltaic cells fell 70 percent in the last decade, leading to an upward trend in the incentive to take advantage of the rooftop solar tax incentives (Solar Energy Industry Association, seia.org, 2021).

Figure 3 shows the growth of solar jobs by category from 2010 to 2020 from the National Solar Jobs Census (Solar Energy Industry Association, 2021). The graphs shows that solar installation jobs are the dominant source of both the level and growth of total solar job. Installation jobs currently account for two-thirds of all solar jobs. Important to note is the time pattern: job growth was slow initially and then took off after 2012, reaching a plateau starting around 2016. This pattern is very similar to the pattern of estimates by Popp and co-authors for the effects of the ARRA green spending. Popp and co-authors interpret their results as indicating that the ARRA appropriations led to permanent job creation. I suggest an alternative hypothesis: the commuting zones that received ARRA green spending appropriations were also areas that were ideal for solar. As a result, households and businesses in those areas were more likely to take advantage of the solar tax incentives, which remained in place long after the ARRA green spending was spent. Thus, the apparent permanent job creation effects of the ARRA green spending are more likely to have been due to the tax incentives for rooftop solar interacting with the declining price of photovoltaic cells.

It would be interesting for future research to study the effects of rooftop solar for an additional reason: its use of labor and land. Installing rooftop solar requires more labor hours per energy unit installed. For example, according to the 2015 National Solar Jobs Census, residential

installations required 40 labor hours per 5kwh, commercial required 36, and utility-scale, 25. Many have argued that utility-scale installations, which involve large solar farms often situated in remote desert areas, are superior because they take advantage of economies of scale. However, this argument neglects two factors. First, rooftop solar reduces the need for transmission lines to carry the energy across long distances. Second, rooftop solar uses land more efficiently and does not disturb endangered habitat. A recent Brookings study highlights the fact that wind and solar energy require at least ten times more land per unit of power produced than fossil fuels do (Gross (2020)). This demand for additional land leads to numerous conflicts over land use. For example, in California climate change activists have clashed with conservationists over the construction of large solar farms in areas with endangered species. In contrast, rooftop solar is installed on existing buildings, near the ultimate user.

THE IMPORTANCE OF COMMUNITY PRESERVING POLICIES As I mentioned in the introduction to my comments, the major motivation for the Popp et al. analysis is determining whether the workers displaced by the decline of fossil fuels can be re-employed in green industries. I have already raised questions about their finding of seemingly permanent job gains from temporary green spending. If the spending does not lead to permanent job gains, then there can be serious impacts on communities.

Consider the example of the mining communities of Asturias, Spain. The Spanish government phased out mining in the Asturias region of Spain, which had been mining coal for hundreds of years, and promised to bring in green jobs and retraining programs. According to numerous reports, the government has not fulfilled its promise. Instead, it started importing cheap coal from China. The older coal miners were pensioned off, preventing large income losses. However, because there are no jobs for the younger people, the towns in the mining areas are being depopulated, with mostly older people left behind (e.g. Benavides (2019)).

The lesson to be learned from the example of Asturias, Spain is that without the prospect of permanent, good paying jobs for younger people, communities decline. The cycle can feed on itself since depopulation leads to reduced local tax revenue. The green transition is likely to face formidable opposition from some quarters if governments cannot develop credible, community-preserving policies.

CONCLUSIONS Popp and co-authors have written a very useful analysis of the possibilities of the green transition providing jobs to fossil-fuel and other workers. In my

discussion, I have raised questions primarily about the estimated permanent effects of the temporary green spending stimulus in the ARRA. Theory predicts that there should be no permanent employment effects of temporary spending at the aggregate level, but since the authors' estimates are at the local level, permanent employment shifts are possible. However, I have also raised the possibility that their estimates may be picking up the effects of another government green incentive, tax credits for rooftop solar. That incentive has been in place since the mid-2000s, and, in conjunction with the declining price of photovoltaic panels, has likely led to an upward trend in green employment. If the ARRA green spending was more likely to be directed to communities that also had more natural solar potential, then the upward trends in job creation found by the authors may be picking up these alternative effects.

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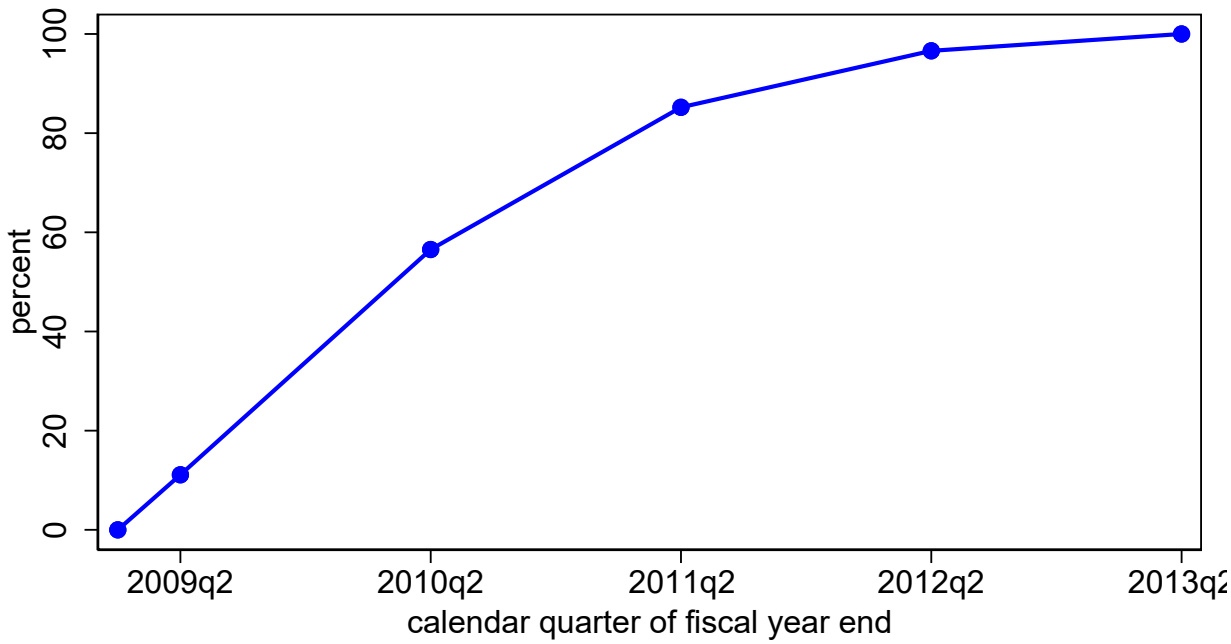
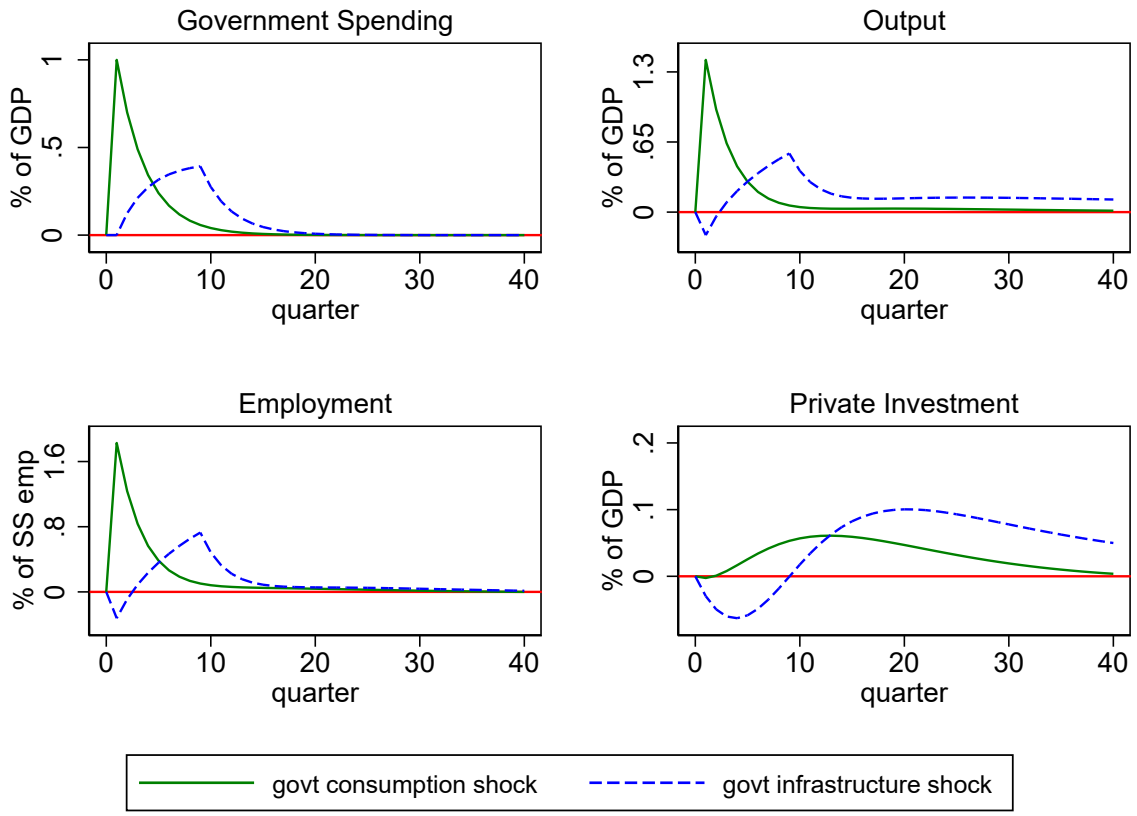
Figure 1. Federal Highway Administration Outlays from the ARRA: Cumulative Percent Spent of Total Appropriation



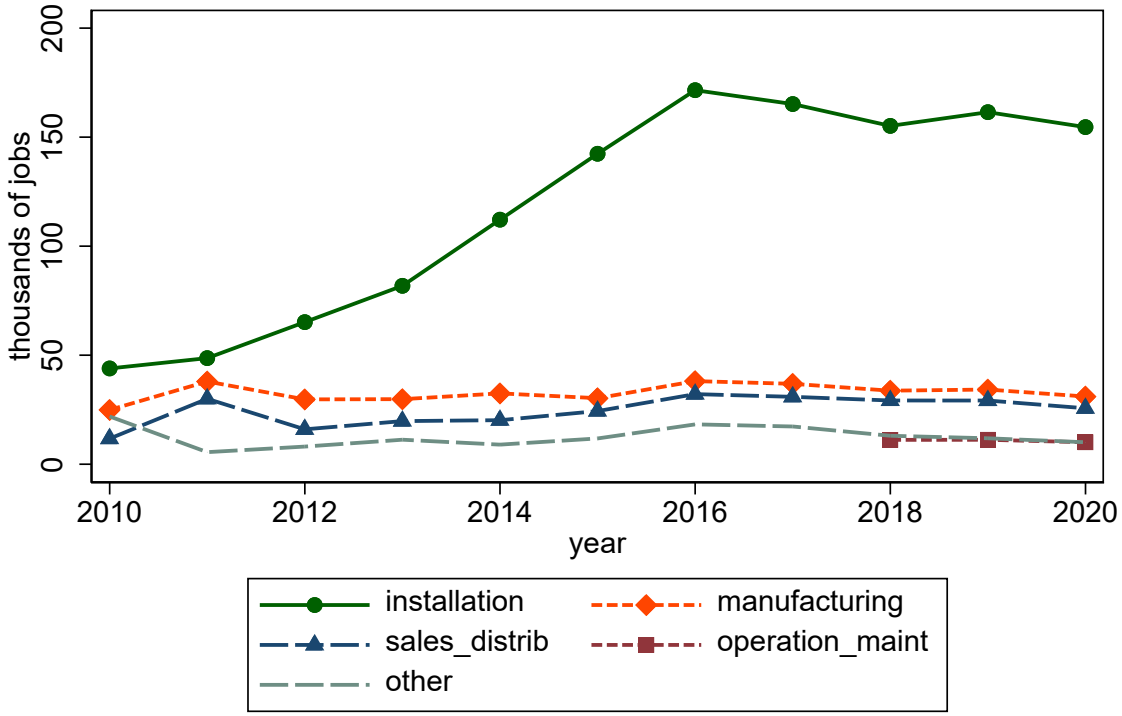
Notes: These data are from Leduc and Wilson's (2017) replication files, state-level data aggregated to the national level.

Figure 2. Macroeconomic Effects of Government Consumption Spending vs. Infrastructure Spending with Delays in a New Keynesian Model.



Notes. This graph shows impulse responses to a shock to government appropriations destined to either government consumption or government infrastructure investment. The impulse responses are based on simulations of the medium-scale New Keynesian model from Ramey (forthcoming). See the text for more details.

Figure 3. Solar Employment by Sector.



Notes. This graph shows employment by sector within the solar industry. The data are from https://www.seia.org/sites/default/files/2020-National-Solar-Jobs-Census-Chart-Data-Public.xlsx , which accompanies the *National Solar Jobs Census 2020* conducted by the Solar Energy Industries Association.