The 2009 Recovery Act: Stimulus at the Extensive and Intensive Labor Margins

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The 2009 Recovery Act: Stimulus at the Extensive and Intensive Labor Margins*

Bill Dupor† and M. Saif Mehkari‡

August 11, 2014

Abstract

This paper (i) estimates the local effects of government stimulus spending on labor market outcomes and (ii) shows how these effects can be obtained from a firm’s optimal policy in the presence of costs to hiring workers. We analyze the American Recovery and Reinvestment Act of 2009 (Recovery Act) using instrumental variables at the county-level. We find that $1 million of government spending increased employment locally by 5.5 persons and also increased wage payments to existing workers by $178,000. Next, we build a model in which a firm meets new government demand with a combination of new hiring and increasing the number of hours for existing workers. Faced with hiring costs and an overtime premium, the firm responds by increasing hours along both margins. Our analysis also provides insight into how government spending policy should be structured to lower the cost of generating new jobs. Finally, we catalog survey evidence from Recovery Act fund recipients that reinforces the importance of the intensive labor margin.

Keywords: fiscal policy, intensive and extensive labor margins, the 2009 Recovery Act.

JEL Codes: D21, D24, E52, E62.

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*The authors thank Emilee Dufford and Peter McCrory for helpful research assistance. A repository containing government documents, data sources, a bibliography, and other relevant information pertaining to the Recovery Act is available at billdupor.weebly.com. The analysis set forth does not reflect the views of the Federal Reserve Bank of St. Louis, the Board of Governors of the Federal Reserve System, or the Federal Reserve System. First draft: March 2014.

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1 Introduction

A primary goal of the American Recovery and Reinvestment Act of 2009 (hereafter, the Recovery Act) was to improve a then significantly depressed employment situation. This paper asks the following question: how much of this spending in a local labor market passed through to greater employment as opposed to a larger wage bill to existing workers?

We view the distinction between payments to new workers versus existing workers as important because, with imperfect insurance of employment income, the brunt of the welfare costs of the 2007-2009 recession was likely borne by workers losing their jobs.\(^1\) Alleviating unemployment through stimulus job creation acts as a crude form of social insurance. As such, increasing the number of individuals at work may have been preferred to increasing the income’s of those already employed.\(^2\)

Our empirical work uses quarterly reports filed by over 570,000 individual recipient organizations (businesses, non-federal government agencies, and nonprofits) of Recovery Act funds. The reports provide zip-code-level detail on spending, allowing us to execute a highly disaggregated analysis.

First, we measure the variation in employment and the total wage bill across counties following the Act’s passage and compare these with the markets’ Recovery Act spending. Following standard techniques, these differences will deliver an estimate of the average treatment effect of the spending.

Since the allocation of Recovery Act spending was likely to be in part endogenous, we use instrumental variables. Our instrument is the highway improvement funds (which totaled $28.8 billion) authorized by the Act. In distributing these federal dollars to the states, most funds were assigned to states according to factors established before the recession, such as each state’s pre-recession highway usage and its number of highway lane-miles. As such, these expenditures are likely to be uncorrelated with the state’s business cycle conditions during the recession.

Next, each state had some discretion in how it distributed dollars across its own regions. While this introduces the possibility for within-state endogeneity, we demonstrate how this discretion did not lead to focused efforts in economically distressed areas; thus, the local highway spending can accurately be treated as exogenous.

Our benchmark empirical finding can be stated as follows: $1 million in Recovery Act spending within a county increased employment locally by approximately 6 persons and the wage bill by $380 thousand.\(^3\)

With a large increase in the wage bill but a small increase in employment, we infer that some Recovery Act dollars, $178 thousand per $1 million spent, went to existing workers in the form of a higher wage rate and/or greater average hours worked. Thus, there was an effect on labor at both

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\(^1\) Research on the welfare cost of business cycles and the importance of uninsurable labor market risk includes works by Imrohoroglu (1989) and Beaudry and Pages (2001).

\(^2\) The above distinction harkens back to the old saying that “The Great Depression wasn’t so bad if you already had a job.”

\(^3\) Importantly, our estimates cannot be interpreted as measures of a “national jobs effect” because of potential cross-county spillovers, such as those resulting from common monetary policies or trade across local markets. For a detailed discussion on this issue, see Nakamura and Steinsson (2013).
the extensive and intensive margins.

In our paper’s theory section, we explore one potential reason for the effect. Organizations meeting the demand for stimulus goods and services may use other margins besides hiring additional workers to increase production.

We build a model to explore this effect and to rationalize the data. In our model, a firm can meet the demand for goods by either hiring new employees and/or by altering the number of hours existing employees work. Changes along both these margins are costly. The firm incurs a cost to hire and fire workers when adjusting along the employment margin, and it faces an overtime premium when adjusting the number of hours existing employees work. Both of these costs are convex. As a result, when faced with a change in demand, the firm optimally adjusts along both margin.

We calibrate our model to data from the highway, bridge, and street construction industry and then study the effect of government spending shocks consistent with Recovery Act data. Our model predicts that it costs the government approximately $148,000 dollars in government spending to generate one additional job for one year that in the long run pays an annual wage of only $47,500. In the model, roughly two-fifths of all government spending goes toward compensating nonlabor inputs and three-fifths toward the wage bill for labor compensation. In turn, of the three-fifths going toward the wage bill, approximately 60% goes toward hiring new workers and 40% toward increasing the hours for existing workers. These findings qualitatively match the estimates delivered by our instrumental variables estimation.

Next, we use our model to perform policy experiments. Our policy experiments provide insight into which type of government policy leads to the lowest cost of job creation. We find that the government should target firms with a large number of employees who are earning a relatively low hourly wage. We also find that it is better for the government to target a small number of firms with large government spending shocks than a large number of firms with small government spending shocks. Regarding the structure of the government spending shock, we find that larger shocks are better than smaller shocks, uncertainty about the magnitude of the government spending shock is helpful, and shocks of both very short and long duration create the most employment.

Our paper relates to two distinct lines of research. First, several studies have used cross-state variation in Recovery Act and instrumental variables to estimate the jobs effects of the law. These include Conley and Dupor (2013), Dupor (2013) and Wilson (2012). In the first part of our paper, we follow the same basic approach except we use county-level data, which results in more precise estimates.

The existing research shows that the Act’s spending component (i.e., excluding tax cuts) increased employment at a cost per job of roughly three to five times that of typical employment compensation in the United States. According to our results, the high cost of increasing employment result in part from producers increasing hours at the intensive rather than the extensive
The second part of our paper ties our work to research on micro-level intensive and extensive adjustment of labor input. Papers along this line include those by Caballero, Engel, and Haltiwanger (1997); Cooper, Haltiwanger, and Willis (2004) and Cooper and Willis (2009); These papers are primarily interested in building models that are simultaneously able to match the macro- and micro-level dynamics of labor demand.

The outline of the paper follows. Section 2 describes the data, explains the estimation approach, and provides our empirical results. Section 3 presents our theoretical model and analyzes the optimal behavior of the firm. Section 4 gives qualitative evidence from survey responses that confirm our findings of an important extensive margin, and the final section concludes.

2 Empirical Analysis

2.1 The Data

The Sample

Our unit of observation is a U.S. county. Counties differ tremendously in size, and there is good reason to believe that labor markets function differently in very populous areas, where a wide variety of differently specialized potential employees may be available to firms, relative to a very low population area. With this heterogeneity in mind, we trim out both of the extreme sizes (in terms of populations) of the distribution.

In particular, we exclude counties with populations less than 10,000 and those with populations greater than 750,000. This leaves us with 2,349 counties, which together have 192 million residents. Summary statistics for our analysis appear in Table 1.

Outcome Variables (ΔJob-Years and ΔWage bill)

We use two employment outcome variables. Both are constructed using data from the Quarterly Census of Employment and Wages.

Our first outcome variable is the average change in employment from the base of 2008:Q4 over the following eight quarters. Let \( Y_{j,k} \) denote employment in county \( j \) in quarter \( k \).

\[
\Delta \text{Job-years}_j = \frac{1}{4 \times \text{Pop}_j} \sum_{k \in K} (Y_{j,k} - \bar{Y}_j),
\]

where \( \Delta \) denotes “change in.” In our benchmark specification, we let \( K = \{2009:Q1,...,2010:Q4\} \). \( \bar{Y}_j \) equals the county \( j \) employment in 2008:Q4.

4Other work on firm problems in the face of non-convex adjustment costs includes papers by Khan and Thomas (2008) and Rust (1987).

5We report results for alternative specifications which vary the set of included counties later in the paper. The upshot of those comparisons is that comparing across very differently sized sample, estimates are imprecise and not stable.
Table 1: Summary statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>10th perc.</th>
<th>90th perc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total obligations, per capita</td>
<td>732.872</td>
<td>1037.421</td>
<td>213.952</td>
<td>1359.460</td>
</tr>
<tr>
<td>FHWA obligations, per capita</td>
<td>95.350</td>
<td>258.194</td>
<td>0.000</td>
<td>233.938</td>
</tr>
<tr>
<td>Total change in job-years, per capita</td>
<td>-0.022</td>
<td>0.030</td>
<td>-0.054</td>
<td>0.007</td>
</tr>
<tr>
<td>Total change quarterly wages, per capita</td>
<td>-0.002</td>
<td>0.002</td>
<td>-0.004</td>
<td>-0.000</td>
</tr>
<tr>
<td>Employment-to-population ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008:Q4</td>
<td>0.353</td>
<td>0.119</td>
<td>0.213</td>
<td>0.507</td>
</tr>
<tr>
<td>2008:Q3</td>
<td>0.357</td>
<td>0.120</td>
<td>0.215</td>
<td>0.512</td>
</tr>
<tr>
<td>2008:Q2</td>
<td>0.348</td>
<td>0.117</td>
<td>0.211</td>
<td>0.499</td>
</tr>
<tr>
<td>2008:Q1</td>
<td>0.354</td>
<td>0.119</td>
<td>0.214</td>
<td>0.507</td>
</tr>
<tr>
<td>2007:Q4</td>
<td>0.356</td>
<td>0.118</td>
<td>0.214</td>
<td>0.508</td>
</tr>
<tr>
<td>Personal income (3-yr. moving average, (\Delta 2006-08), thousands of $)</td>
<td>0.678</td>
<td>0.741</td>
<td>-0.019</td>
<td>1.494</td>
</tr>
<tr>
<td>Population per square mile</td>
<td>182.253</td>
<td>596.987</td>
<td>18.100</td>
<td>365.050</td>
</tr>
<tr>
<td>Share of employment in manufacturing (%)</td>
<td>15.260</td>
<td>10.134</td>
<td>3.779</td>
<td>29.675</td>
</tr>
<tr>
<td>Log of population</td>
<td>10.714</td>
<td>1.020</td>
<td>9.537</td>
<td>12.210</td>
</tr>
<tr>
<td>Wages-to-population ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008:Q4</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>2008:Q3</td>
<td>0.003</td>
<td>0.001</td>
<td>0.002</td>
<td>0.005</td>
</tr>
<tr>
<td>2008:Q2</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>2008:Q1</td>
<td>0.003</td>
<td>0.002</td>
<td>0.002</td>
<td>0.005</td>
</tr>
<tr>
<td>2007:Q4</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Total obligations = $ 153 billion  
FHWA obligations = $ 17 billion  
Number of observations = 2,310

Notes: The unit of observation is a U.S. county. The above sample excludes counties with populations less than 10,000, populations greater than 750,000, and several counties due to data availability. FHWA, Federal Highway Administration; SD, standard deviation.
The \((1/4)\) term transforms the variable from job-quarters to job-years. We also scale by each counties’ 2010 population, denoted \(\text{Pop}_j\).

Our second outcome variable is the accumulated change in the per capita wage bill in the first two years following passage, relative to a 2008:Q4 benchmark:

\[
\Delta \text{Wage bill}_j = \frac{1}{\text{Pop}_j} \sum_{k \in K} (P_{j,k} - \bar{P}_j),
\]

where \(P_{j,k}\) and \(\bar{P}_j\) are the compensation amounts (in millions of dollars) to employees during the respective periods.

Our choice of a two-year (rather than longer) horizon stems from two factors: (i) Policymakers were focused on creating jobs during the early phase of the Act, when the labor market faced its greatest stress; and (ii) the precision of our estimates falls as we push the horizon farther into the future.

**Treatment Variable (\(V_j\))**

First, we define \(\tilde{V}_{j,k}\), as the Recovery Act dollars obligated to organizations (i.e., non-federal government agencies, non-profit organizations and firms) within county \(j\) cumulative through \(k\) quarters since the Act’s passage. Obligated dollars are defined as dollars committed by the federal government to recipient organizations. These amounts are constructed using quarterly reports filed by recipients of contracts, grants, and loans (CGLs) to the web site FederalReporting.gov.\(^6\)

Federal agencies issuing the largest amounts of this form of aid included the Departments of Education, Health and Human Services, Transportation, and Energy. These data give us the zip code level of spending by specific CGL awardees, as well as their sub-recipients, vendors, and sub-vendors.

The data are organized so that dollars are obligated to prime recipients of awards and sub-recipients of awards.\(^7\) Each recipient organization reports both its award amount and a point-of-performance zip code. We use these zip codes to allocate award amounts to the various markets. This gives us a market-specific measure of total CGL awards, which forms the treatment (following one adjustment as described next).

The data also contains spending on vendors by the two types of recipients. Each vendor observation contains the following relevant information: a vendor name, an associated award number, a payment amount, and the zip code of the vendor’s business headquarters.\(^8\)

---

\(^6\) After processing and data verification by the Recovery Accountability and Transparency Board, these data were posted on the website Recovery.gov. A user’s guide for these data is contained in Recovery Accountability and Transparency Board (2009).

\(^7\) Our sample does not include sub-awards valued at less than $25,000 because these recipients were not required to provide zip codes for these sub-awards; which totaled $5.74 billion.

\(^8\) Our sample does not include vendor and sub-vendor payments valued at $25,000 or less because these recipients were not required to provide zip codes for these payments, which totaled $2.12 billion. Our analysis requires one additional adjustment to the original data. Suppose an awardee in market \(Q\) pays $10,000 to a vendor headquartered...
We scale by the county population and report values in millions of dollars:

\[ V_{j,k} = \frac{\hat{V}_{j,k}}{(1e + 6) \times Pop_j}. \]

Finally, we set \( k = 2010:Q4 \) for every specification and suppress the \( k \) index in the remainder of the paper.

Note that not every component of the Act is included in the treatment variable. The treatment does not include tax benefits to persons or firms, direct transfer payments from the federal government (e.g., Social Security transfers), or unemployment insurance benefits.  

**Instrument Variable \( (V^H_j) \)**

Because the Recovery Act obligations variable may be an endogenous regressor, we use the cumulative Recovery Act highway obligations as of 2010:Q4 for an instrument. The Act allocated roughly $28.8 billion in funds to highway infrastructure. Much of this was allocated by formula across the states. For example, federal highway dollars were allocated using pre-Act apportionment formulas that depended on criteria including the state’s share of total eligible highway lane-miles and its share of total vehicle-miles traveled. We denote this instrument \( V^H_j \). It is constructed in the same manner as \( V_j \) except we include only Recovery Act Federal Highway Administration (FHWA) obligations in its construction.

Although federal allocations of Recovery Act highway aid to states were almost entirely formula, endogeneity could arise at the county-level allocations within a state. Note that states were effectively responsible for allocating funds to projects geographically within their borders. Bearing this in mind, a state might have decided to allocate more highway funds to counties harder hit by the recession. On the other hand, state officials may have directed funds to growing, economically healthy labor markets in need of more infrastructure. Growing labor markets may have, in turn, been more immune to the effects of the recession. In this case, our estimates should be interpreted as an upper bound on the jobs effect of Recovery Act spending.

We note that state governments were given several (sometimes conflicting) objectives for project selection. First, the Act required states to obligate their funds before October 2011 and choose projects that could be completed within a 3-year time frame. Failure to meet these latter requirements resulted in prespecified and harsh financial penalties on states. Second, states were instructed to give priority to highway projects located in economically distressed areas. The legislation gave two separate criteria for economic distress: a low per capita income or a high unemployment rate, both relative to their national averages. The operational meaning of “give priority to” was not

in market \( R \). This requires us to reduce the total aid amount to market \( Q \) by $10,000 and increase the total aid amount to market \( R \) by $10,000.

9The included and excluded agencies are listed in the appendix (see Table A.1).

10The Act specified the definition of economically distressed by referencing Section 403 of the Public Works and Development Act of 1965. Section 403 gave the two criteria. A third criterion is listed in Section 403, which
defined in either the Act itself or the administrative guidance written by the Federal Department of Transportation for the state officials. Also, there were no penalties for missing the objective or assessments by federal officials as to whether the “economically distressed” criteria were met. Third, state agencies also sought to spend Recovery Act highway dollars on highways and bridges with the greatest need.

To assess whether states actually weighted aid towards more or less distressed areas, we run a county level regression of FHWA Recovery Act aid on dummy variables for the two measures of stress defined above: (i) if per capita income is less than 80% of the national average, (ii) if a county’s unemployment rate is below the national average. Each takes a value of 1 if the respective distress criterion is satisfied.

The results are presented in Table 2. The left-hand-side variable is FHWA obligations per capita. In addition to the dummy variables, the right-hand-side includes the population, the natural log of the population, and a constant. The coefficient on the unemployment rate dummy was not statistically different from zero. Thus, the estimates suggest that states did not target highway aid to counties particularly hard hit by the recession. Column (i) contains the estimates for all counties. The coefficient on the per capita income dummy is -20.09. This implies that a county with low personal income on average received less highway aid. Column (ii) estimates the same equation except the sample is extended to include all counties; the results are very similar. This suggests that aid went to areas with healthier economics. Thus, as noted above, our estimates should be interpreted as upper bounds on the jobs and wage bill effects.

The absence of states tying the Act’s funding to high-unemployment counties might be explained related to areas with “economic adjustment problems.” These areas required designation by the U.S. Secretary of the Department of Transportation. None of said designations were given by the Secretary for the Recovery Act.
by the perception of the Act’s requirements by some state transportation officials. Meyers (2013), based on his interviews with a sample of these officials, writes “The most important changes that state officials recommended for future transportation programs aimed at achieving the greatest economic stimulus effect were, in order of mentioning: 1. Select projects on the basis of greatest economic impact; do not artificially constrain the selection with requirements for economically depressed designation and geographic balance.”

**Conditioning Variables**

*Common Controls*

We simultaneously estimate equations for ∆Job-years and ∆Wage bill. Both equations have the following common control variables: eight Census region dummies, the share of employment in manufacturing, the natural log of the population, the population density, and a constant. We also control for the pre-Act income level in each county using a 3-year moving average of annual personal income per capita (from 2006 to 2008). Each equation also has its own separate set of controls.

*Equation-Specific Controls*

Define $F(L) = [L, L^2, ..., L^5]$. For the ∆Job-years equation, the lag variables, $F\left(\frac{\text{Emp}}{\text{Pop}}\right)$, are included as additional conditioning variables. Here, $\frac{\text{Emp}}{\text{Pop}}$ is the employment-to-population ratio in 2009:Q1. For the ∆Wage bill equation, we include $F\left(\frac{\text{Wage bill}}{\text{Pop}}\right)$.

### 2.2 Estimation and Results

Let $X_1 = [V, \text{Common Controls}, F\left(\frac{\text{Emp}}{\text{Pop}}\right)]$. $X_2$ is identical to $X_1$ except we replace the lagged values of $F\left(\frac{\text{Emp}}{\text{Pop}}\right)$ with $F\left(\frac{\text{Wage bill}}{\text{Pop}}\right)$. Next, $Z_1$ is identical to $X_1$ except we replace $V$ with $V^H$. Similarly, $Z_2$ is identical to $X_2$ except we replace $V$ with $V^H$. Define the error terms from the two equations as

$$
\varepsilon_1 = \Delta \text{Job-years} - X_1\beta_1 \\
\varepsilon_2 = \Delta \text{Wage Bill} - X_2\beta_2
$$

We estimate the pair of equations by generalized method of moments (GMM), which in this case is similar to three-stage least squares (3SLS). System estimation via GMM permits us to test cross-equation restrictions on parameter estimates. In constructing the optimal GMM weighting matrix, we assume

$$
E\left[ \begin{bmatrix} Z_1\varepsilon_1 \\ Z_2\varepsilon_2 \end{bmatrix} \begin{bmatrix} Z_1'\varepsilon_1 \\ Z_2'\varepsilon_2 \end{bmatrix} \right] = \begin{bmatrix} \sigma_{11}E(Z_1Z_1') & 0 \\ 0 & \sigma_{22}E(Z_2Z_2') \end{bmatrix}.
$$
Thus, the cross-equation moment conditions are conditionally independent. Within each equation, we assume conditional homoskedasticity.

The first column of Table 3 contains the benchmark estimates of the effect of Recovery Act spending on job creation (i.e., $\Delta$Job-years). The coefficient on obligations equals 5.54 (S.E. = 2.16). This implies that $1 million in Recovery Act funding increased employment by 5.54 jobs of duration equal to one year. This translates into a cost per job-year of $181,000. This is in line with the baseline estimates found in Conley and Dupor (2013).

Although we estimate the model by GMM, we assess instrument relevance by reporting the corresponding key “first-stage” from the 3SLS problem underlying our estimation strategy. These coefficients are from the least squares estimates and appear near the bottom of the first column of Table 3. The $t$-statistic on the FHWA instrument equals 13.4 and the partial $F$-statistic equals 180. Both coefficients support the strong instrument assumption to which we appeal.

The second column of Table 3 contains the estimates of the wage bill equation. The coefficient equals 0.384 (S.E. = 0.16). This implies that adding $1 million of Recovery Act spending into a labor market results in $384,000 worth of additional wage payments into that county’s economy in the first two years following the Act’s passage.

Next, we use the coefficients from the job-year and wage bill estimates to decompose the wage bill effect into wage payments to newly hired versus existing workers. To compute this decomposition, we must decide whether the wage income was earned on a job either created or saved as a result of the Act. We assume that the annual wage payment to a hired worker resulting from the Recovery Act equals $37,100. This amount is roughly equal to the typical compensation to a full-time worker in the United States in 2009. We compute this number based on the following evidence. According to the 2009 Occupational Employment Statistics, the median hourly wage was $15.95 in 2009. According to the Current Employment Statistics, the average hours worked per week in 2009 was 33.9. The Employer Cost for Employee Compensation reported that wages accounted for 70% of total compensation. Assuming a 48-week work year, this implies a typical annual employment compensation of roughly $37,100.

Then, the wage payments to newly hired or retained workers resulting from $1 million of Recovery Act funding was approximately $206,000 ($ = 5.54 \times 37,100). The payment to existing workers, in turn, equaled approximately $178,000 ($834,000 - $206,000). This value, $0.178 million, is presented near the bottom of Table 3 in the row labeled “Intensive margin payments.” Below this estimate, we report its $p$-value, which equals 0.06.

In the next section, we study the explicit dynamic optimization problem of a firm that chooses whether to meet government demand by employing new workers or alternatively increasing the hours of existing workers. The model is capable of qualitatively explaining the above empirical finding.

One of the previously existing puzzles in Recovery Act research is why the cost per job of
Table 3: 3SLS estimates of the effect on labor market outcomes of Recovery Act spending (benchmark specifications)

<table>
<thead>
<tr>
<th></th>
<th>JY Change</th>
<th>WB Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery Act obligations ($1 million p.c.)</td>
<td>5.54** (2.16)</td>
<td>0.38** (0.16)</td>
</tr>
<tr>
<td>Manufacturing share</td>
<td>-0.04*** (0.01)</td>
<td>-0.00*** (0.00)</td>
</tr>
<tr>
<td>Income (3-yr moving average)</td>
<td>-2.96*** (1.09)</td>
<td>-0.12* (0.07)</td>
</tr>
<tr>
<td>Log of population</td>
<td>0.97 (0.90)</td>
<td>0.09 (0.07)</td>
</tr>
<tr>
<td>Population per square mile</td>
<td>0.00 (0.00)</td>
<td>-0.00 (0.00)</td>
</tr>
<tr>
<td>Intensive margin Payments ($ millions)</td>
<td>0.178</td>
<td>0.060</td>
</tr>
<tr>
<td>p-Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2310</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.458</td>
<td>0.378</td>
</tr>
</tbody>
</table>

First-stage results
- t-statistic FHWA Instrument: 13.432
- Partial F-statistic: 180.424
- $R^2$, 1st-stage: 0.149

Notes: JY, job-years; WB, wage bill; p.c., per capita. Intensive margin payment = WB change − 0.0371 × JY change. standard errors in parentheses. *** denotes 1%, ** 5% and * 10% significance. Each specification also includes eight Census region dummies, five lags of the employment-to-population ratio or the wage bill per capita, and a constant.
workers has been so high, (e.g. Conley and Dupor (2013), and Dupor (2013)). For the labor markets included in this sample, our estimates suggest two reasons. First, nearly half of the Recovery Act spending does not pass through to a larger wage bill. We suggested potential reasons for that phenomenon above. Second, more than one half of the remaining wage payments that do pass through to labor end up in the hands of existing workers – not new hires.

Why didn’t more of the Recovery Act dollars translate into payments to workers? There are many potential sources of “leakage.” First, a fraction of these dollars likely went to firm profits or payments to other factors of production besides labor. Also, some dollars likely went abroad or to other local markets. Next, most Recovery Act spending was channeled through state and local governments, which might have deposited part of their aid into rainy day funds.\(^{11}\) Finally, some workers who took Recovery Act-financed jobs were leaving other jobs. Thus, if a worker leaves a $30,000 annual salary job to take a $30,000 Recovery Act-financed job, then \textit{ceteris paribus} there was no net effect on that labor market’s wage bill.\(^{12}\)

For comparison, Table 4 provides the seemingly unrelated regressions estimates corresponding to the benchmark 3SLS specification except all of the variables are treated as exogenous. This specification is analogous to a least-squares counterpart of the benchmark model, except we allow for covariation of the two alternative treatment parameter estimates.

Table 4 has two key features. First, the seemingly unrelated regressions (SUR) coefficients are estimated more precisely relative to the 3SLS, as would be expected. Second, instrumenting with highway spending in moving from Table 4 to Table 3 increases the size of the point estimates of the effect of Recovery Act obligations’ on each county variable in every column.

Table 5 provides a number of alternative specifications. First, we report the benchmark estimates and each column that follows contains a variant on the benchmark specification. In every specification, there is a statistically significant effect on employment, which range from 3.72 to 6.19 job years per $1 million spent. In two of the alternative specifications (dropping the common controls or dropping the region dummies), there is a statistically significant effect on the wage bill. For each of these specifications, there is a statistically significant payment along the intensive margin. This is consistent with our benchmark finding.

In two specifications, we cannot reject a zero impact on the wage bill. This occurs when we either: (a) extend the sample to include the smallest counties, or (b) use population weighted regressions. Both of these estimates demonstrate how our results may only apply to medium sized counties, as we stressed in our paper’s introduction.

In the next section, we build a dynamic model capable of explaining the intensive margin effect observed in the benchmark specification.

\(^{11}\)Early work on how spending and savings patterns of sub-national governments change with receipt of federal grants includes Bradford and Oates (1971).

\(^{12}\)Based on survey evidence of Recovery Act aid recipients, Jones and Rothschild (2011) find that half of employees hired for projects financed by the Recovery Act were leaving other jobs.
Table 4: SUR estimates of the effect on labor market outcomes of Recovery Act spending (benchmark specifications except all variables are treated as exogenous)

<table>
<thead>
<tr>
<th></th>
<th>County Analysis</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>JY Change</td>
<td>WB Change</td>
</tr>
<tr>
<td>Recovery Act obligations ($1 million p.c.)</td>
<td>2.84***</td>
<td>0.21***</td>
</tr>
<tr>
<td></td>
<td>(1.07)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Manufacturing share</td>
<td>-0.04***</td>
<td>-0.00***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Income (3-yr moving average)</td>
<td>-3.40***</td>
<td>-0.15**</td>
</tr>
<tr>
<td></td>
<td>(1.03)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Log of population</td>
<td>0.77</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.94)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Population per square mile</td>
<td>0.00</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Intensive Margin Payments($ millions)</td>
<td>0.102</td>
<td></td>
</tr>
<tr>
<td>p-Value</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2310</td>
<td></td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.465</td>
<td>0.385</td>
</tr>
</tbody>
</table>

Notes: JY, job-years; WB, wage bill; p.c., per capita. Intensive margin payment = WB change−0.0371 × JY change. standard errors in parentheses. *** denotes 1%, ** 5% and * 10% significance. Each specification also includes eight Census region dummies, five lags of the employment-to-population ratio or the wage bill per capita, and a constant.

Table 5: 3SLS estimates of the effect on labor market outcomes of Recovery Act spending (alternative specifications)

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Drop region dummy variables</th>
<th>Including counties with pop. less than 10,000</th>
<th>Population weighted</th>
<th>Drop common controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job-years</td>
<td>5.54**</td>
<td>6.19***</td>
<td>3.72*</td>
<td>5.50**</td>
<td>5.17**</td>
</tr>
<tr>
<td></td>
<td>(2.16)</td>
<td>(2.17)</td>
<td>(1.94)</td>
<td>(2.19)</td>
<td>(2.02)</td>
</tr>
<tr>
<td>Wage bill</td>
<td>0.38**</td>
<td>0.43***</td>
<td>0.20</td>
<td>0.29</td>
<td>0.38***</td>
</tr>
<tr>
<td></td>
<td>(0.16)</td>
<td>(0.16)</td>
<td>(0.15)</td>
<td>(0.18)</td>
<td>(0.15)</td>
</tr>
<tr>
<td>Intensive margin estimate</td>
<td>0.178</td>
<td>0.199</td>
<td>0.058</td>
<td>0.091</td>
<td>0.190</td>
</tr>
<tr>
<td>Intensive margin p-val.</td>
<td>0.060</td>
<td>0.045</td>
<td>0.545</td>
<td>0.513</td>
<td>0.037</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>2310</td>
<td>2310</td>
<td>2848</td>
<td>2310</td>
<td>2349</td>
</tr>
</tbody>
</table>

Notes: JY, job-years; WB, wage bill. Intensive margin payment = WB change−0.0371 × JY change. standard errors in parentheses. *** denotes 1%, ** 5% and * 10% significance.

13
3 A Structural Model of a Highway Construction Firm

3.1 The Model

We consider the following dynamic decision-theoretic model of the firm.

The firm in our model uses labor to produce goods and can adjust the amount of labor by changing the number of total employees and/or the number of hours each employee works. The number of employees and the hours per employee jointly determine both the firm’s output and its costs.

The firm’s output, \( y_t \), is given by

\[
y_t = (e_t h_t)\alpha L^{1-\alpha}
\]

where \( e_t \) is the number of employees, \( h_t \) is the number of hours each employee works, \( L \) is a proxy for nonlabor inputs into production such as land or a fixed amount of capital, and \( \alpha \) gives the labor share in production.

Next, the firm static cost function is

\[
C(e_t, e_{t-1}, h_t, \psi_t) = w(h_t)e_t + \psi_t |e_t - e_{t-1}| \text{ with } \psi_t \sim \text{i.i.d } U(0, 2\bar{\psi})
\]

with

\[
w(h) = w_0 + w_1 h^2.
\]

The cost function has two components. The first component, \( w(h_t)e_t \), is the wage bill. The firm’s wage bill depends on the per employee wage, \( w(h_t) \), which in turn, as seen in (3.3), depends on the hours worked by each employee. In (3.3), \( w_0 \) denotes a measure of the base wage paid to each worker irrespective of how many hours the worker provides, while \( w_1 h^2 \) is the marginal effect of hours on the wage. Further, \( w_1 h^2 \) can be rewritten as \( (w_1 h) h \), where \( (w_1 h) \) gives the hourly wage and \( h \) the number of hours each employee works. Note that as \( h \) increases, the hourly wage also increases; this results in an overtime premium parameterized by \( w_1 \).

The second component, \( \psi_t |e_t - e_{t-1}| \), is the cost of hiring/firing. This component captures the cost a firm must pay when hiring or firing a worker and is in addition to the wage paid to this worker. We assume \( \psi \) is stochastic. The stochastic nature of these costs can be viewed as a proxy for time-varying idiosyncrasies in the hiring/firing process. For example, on the hiring side a firm often spends resources training new employees. The resources it spends depend on the idiosyncratic skill level of a new employee.

\[\text{See Caballero and Engel (1993); Caballero, Engel, and Haltiwanger (1997); Cooper, Haltiwanger, and Willis (2004), Cooper and Willis (2009); and Bloom (2009) for similar models of the labor market.}\]
For our baseline model we study the individual-firm response to an unanticipated increase in government spending \((G_t)\) for \(T\) quarters starting in period 1:

\[
G_t = \begin{cases} 
(1 + \gamma G)G & t \in [1, T] \\
G & t > T
\end{cases}
\]  

(3.4)

In Section 3.4, we explore other types of government spending shocks, including those with a stochastic aggregate component.

Consequently, the individual firm’s cost minimization problem can be stated in recursive form as follows:

\[
C_N(e_{t-1}; \psi_t) = \min_{e_t} \{C(e_t, e_{t-1}, h_t; \psi_t) + \beta E [C_N(e_t; \psi_{t+1})]\}
\]  

(3.5)

s.t.

\[
\bar{G} + P = (e_t h_t)^\alpha L^{1-\alpha}
\]

(3.6)

and

\[
C_G(e_{t-1}; \psi_t, \tau) = \begin{cases} 
\min_{e_t} \{C(e_t, e_{t-1}, h_t; \psi_t) + \beta E [C_G(e_t; \psi_{t+1}, \tau - 1)]\} & \text{if } \tau > 0 \\
C_N(e_t; \psi_t) & \text{if } \tau = 0
\end{cases}
\]  

(3.7)

s.t.

\[
(1 + \gamma G)\bar{G} + P = (e_t h_t)^\alpha L^{1-\alpha}
\]

(3.8)

Here, \(C_N\) gives the Bellman equation for the periods when government spending is, and is expected to stay, at its steady-state level. \(C_G\) is the Bellman equation for periods of increased government spending. The variable \(\tau\) in \(C_G\) gives the number of remaining periods of increased government spending.

For our baseline exercise, we assume that before period 1 the level of government spending was at its steady-state level and that the firm expects this level to remain unchanged in the future. This value function is denoted as \(C_N\). We then assume that in period 1 there is an increase in government spending for \(T\) periods. As a result, the firm’s value function in period 1 is given by \(C_G\) with \(\tau = T\), indicating that for the next \(T\) periods, including the current period, there will be increased government spending.

### 3.2 Calibration

We calibrate our model to match firm level facts from the U.S. highway, street, and bridge construction industry. In addition to being a significant component of Recovery Act government spending, this sector has the richest available data from which to construct the calibration.
We first pick the labor share in production, \( \alpha \), and the discount factor, \( \beta \), to be 0.6 and 0.985, respectively. These are standard values. Table 6 presents all of the calibrated values.

Next, we calibrate \( A \), \( w_0 \), and \( w_1 \) such that the steady-state hourly wage, average workweek, and per firm employment in the model match these variables for the highway, bridge, and street construction industry in the data. In the Current Employment Statistics dataset the average hourly wage in this industry was $22 in 2008, and the sectoral average workweek was 41.5 hours, for a total of 539.5 hours per quarter. We then look to the Business Employment Dynamics dataset to determine the per firm employment in this sector. There is a great deal of heterogeneity in this regard; we choose to calibrate the model to medium-sized firms (specifically, those with between 100 and 499 employees). In 2008, there were 722 firms in this size range. The average number of employees within this size range was 178. In 2008, together these medium-sized firms paid $5.92 billion in compensation to labor; the total industry-wide compensation was $19.1 billion. Thus, 31\% of all compensation in the industry was made by firms in this size range. For our calibration we assume that sales in the industry, by firm size, were proportional to the compensation in the industry.

To determine the steady-state level of government demand, \( \bar{G} \), we use data from the FHWA. According to the FHWA, the total value of capital outlays paid for by government funds (independent of the revenue source) in 2007 was $62.5 billion.\(^{14}\) Thus, we assume that $19.4 billion was the revenue earned by firms in this size range. Dividing this amount by 722 firms implies that firms of this size did, on average, $26.8 million of business due to government demand. As a result, we set \( \bar{G} = $6.7 \) million at the quarterly frequency.

We direct our attention to the Recovery Act recipient reports to calibrate the size of the government spending shock to an average firm in the highway, bridge, and street construction industry. We need to construct the value of a typical Recovery Act contract received by a firm. From the recipient reports we can compute the distribution of contract amounts paid to each contractor on these federal aid highway projects. For every vendor with a contract of at least $25,000, we know the vendor’s name, the cumulative amount billed by the vendor in each quarter and the federal agency that funded the project (for which the vendor was hired). The spending amounts we calculate are only for FHWA-administered funds. Each amount is also vendor specific but accumulated across all contracts for that particular vendor.\(^{15}\)

While we know the identity of individual vendors for Recovery Act projects, we do not know the gross revenue (combining Recovery Act and non Recovery Act contracts) of particular vendors. Therefore, we proceed by assuming that the “typical” medium-sized firm did $26.8 million of business as computed above. Next, we assume that the medium-sized firms received the medium-

\(^{14}\)The value for this statistic was not available in 2008.

\(^{15}\)A few examples may be helpful here. FNF Construction of Tempe Arizona, had one contract, for roadway rehabilitation, on which it earned $814,000. A&J Construction of Brookfield, Connecticut, had seven contracts for various highway projects, ranging in value from $250,000 to $3.5 million and totaling $4.0 million.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>0.60</td>
<td>Labor share in production</td>
<td>Standard value</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.985</td>
<td>Discount factor</td>
<td>Standard value for quarterly model</td>
</tr>
<tr>
<td>$L^{1-\alpha}$</td>
<td>6959.1</td>
<td>Level of nonlabor inputs</td>
<td>Jointly chosen to match highway construction sector data: Average hourly wage of $22, number of employees per firm of 174, hours per employee of 539.5 hours/quarter (41.5 hours/week)</td>
</tr>
<tr>
<td>$w_0$</td>
<td>5934.5</td>
<td>Wage function parameter 1</td>
<td></td>
</tr>
<tr>
<td>$w_1$</td>
<td>0.0204</td>
<td>Wage function parameter 2</td>
<td></td>
</tr>
<tr>
<td>$G$</td>
<td>$6.70$ mil.</td>
<td>Steady-state government sector spending</td>
<td>Average annual government demand is $26.8 million</td>
</tr>
<tr>
<td>$T$</td>
<td>8</td>
<td>Duration of government spending shock</td>
<td>Set at 2 years</td>
</tr>
<tr>
<td>$\gamma_G$</td>
<td>0.103</td>
<td>Magnitude of government spending shock</td>
<td>To match a total government spending shock of $5.52$ million over 2 years</td>
</tr>
<tr>
<td>$\bar{\psi}$</td>
<td>$13,750$</td>
<td>Average hiring/firing cost per employee</td>
<td>Conditional on changing the employment level, the firm on average pays a cost of $\approx 5%$ of annual wage to hire or fire a worker</td>
</tr>
</tbody>
</table>
sized total contract values. With this assumption, we can use the recipient reported data to show that the medium-sized firm received a median contract of $5.52 million and an average contract of $7.22 million. That is, the typical medium-sized firm received an approximately 20.6% positive shock due to Recovery Act spending. We assume the spending is spread over a two-year period (i.e., $T = 8$ and $\gamma_G = 0.103$).

Finally, the hiring/firing costs in the model are distributed uniformly, $\psi_t \sim \text{i.i.d} U(0, 2\overline{\psi})$. We choose $\overline{\psi} = $13,750, such that for the baseline model conditional on hiring or firing, an employee the firm’s hiring/firing cost is $2,400 or $\approx 5\%$ of annual per employee wage.

3.3 Results

Figure 1 plots the expected response of the firm to an eight-quarter uniform increase in government demand. Meeting the additional government demand requires the firm to increase its total number of labor hours, which it accomplishes by either hiring new employees and/or increasing the number of hours each employee works (Recall that adjustment along both these margins is costly). If the firm increases the number of employees, it must pay hiring/firing costs, while if it increases the number of hours each employee works, the per employee wage increases due to the overtime premium. The optimal level of adjustment along these margins thus depends on the relative costs of adjusting along each margin. For our baseline calibration the costs of increasing labor hours along either margin are convex, and thus, as seen in panels (b) and (c) of Figure 1, there is a partial adjustment along both margins: Both employment and hours per employee rise in response to a government spending shock.

Our baseline results stand in stark contrast to an economy with no hiring/firing costs. In such an economy, adjustment along the employment margin would be costless and, as seen in panel (b) of Figure 1, the firm would meet its additional labor hours demand by adjusting only along the employment margin. As a result, frictions in the hiring/firing process play an important role in explaining why firms adjust along both the employment margin and hours per employee margin.

The presence of stochastic hiring/firing costs implies that the firm optimally waits to receive a sufficiently low draw before adjusting along the extensive margin. In response to a government spending shock, the firm’s adjustment along the employment margin is not necessarily immediate. As seen in panel (d) of Figure 1 there is a less than 50% chance of the firm hiring new employees immediately following the government spending shock. If we view the stochastic hiring/firing costs as resulting from variations in training costs, then we can explain this optimal waiting time by alluding to a firm that finds it optimal to increase the amount of hours its current employees work as it waits to acquire a sufficiently skilled worker who requires low training costs.

Next, if we envision our expected response as a proxy for the aggregate industry response, then the presence of stochastic hiring/firing costs implies that adjustment along the employment margin at industry-level will be gradual. This industry level gradual adjustment has two interesting
Figure 1: Impulse Responses to Government Spending Shock (Baseline)
features. First, the peak effect of government spending occurs a few periods before the end of the spending shock (See panel (b) of Figure 1). Second, the effects of government spending on the employment margin, albeit small in magnitude, last for a number of periods following the end of the government spending shock. The stochastic nature of the hiring/firing costs explains both of these features. The firm adjusts only along the employment margin when the stochastic costs are low. As a result, having perfect foresight with regard to the length of the shock, the firm hires new workers in the first few periods if its costs are low. Then, in anticipation of the end of government spending, if its costs are low the firm starts firing workers in the periods preceding the end of the stimulus causing the peak response to occur a few periods in advance of the end of the shock. The firing process continues after the end of the shock as the average firm waits for a sufficiently low firing cost to adjust downward along the employment margin. The firm has the flexibility to wait for a low hiring/firing cost because it can meet any shortfall or abundance in employees by adjusting the average hours per employee.

Finally, panel (e) of Figure 1 gives the cumulative effect of government spending on employment. Our baseline government spending shock of $5.52 million uniformly distributed in time over 8 quarters generates 37.4 new-job years. This translates to approximately $148,000 in government spending per new job-year created. This is in contrast to the calibrated per year steady state wage of $47,500 in the highway construction sector. In our theoretical model, similar to our empirical results, government spending does not directly translate dollar for dollar into new jobs. Our results show that the government will need to spend significantly more than $47,500 to generate a new job in this sector. There are two reasons for this. First, not all new labor spending goes toward creating new jobs. As discussed above, a significant fraction of new labor spending in the economy goes toward increasing the labor hours of current employees due to the costs associated with the hiring/firing process. Second, the production of new goods requires a number of factors in addition to labor. As a result a nontrivial fraction of the revenue generated from new government spending goes toward compensating nonlabor inputs, $L$, such as land. It should be noted that even though our model does not measure such externalities, compensating nonlabor inputs can generate jobs in other sectors. Our empirical estimate does measure these externalities as long as the jobs are created in the same local labor market.

The baseline entry of Table 7 quantitatively accounts for why a new job-year in our model costs $148,000. The direct cost of hiring a new worker and paying this worker one year’s worth of wages is endogenously determined in the model to be approximately $51,200. However, because only 60% of all labor spending goes toward hiring new workers, hiring this worker means the firm must increase its labor spending by $51,200 \times 0.6 \approx $85,333. In turn, only 57.8% of the increased government spending translates into labor spending at the firm level. Thus, the government must spend $85,333 \times 0.578 \approx $147,700 to induce the firm to increase its labor spending by $85,333. In sum, the cost of one new job-year is $148,000 in government spending dollars and $85,000 in wage bill
Table 7: Employment and wage bill effects from a firm’s optimal response to an increase in demand for government goods

<table>
<thead>
<tr>
<th>Total Increase in Govt. Spending (ΔG; $ thousands)</th>
<th>Additional Spending on Employees (Δ Wage Bill)</th>
<th>Total New Job-Years Created</th>
<th>Cost/Job-Year ($ thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (% of ΔG)</td>
<td>Only Current Employees (% of Total)</td>
<td>Only New Employees (% of Total)</td>
</tr>
<tr>
<td>Baseline model</td>
<td>5,520</td>
<td>57.8</td>
<td>40.0</td>
</tr>
<tr>
<td>Number of employees / share of labor compensation</td>
<td>5,520</td>
<td>28.9</td>
<td>40.2</td>
</tr>
<tr>
<td>87 employees (50% of baseline)</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>174 employees (baseline)</td>
<td>5,520</td>
<td>86.7</td>
<td>40.2</td>
</tr>
<tr>
<td>261 employees (150% of baseline)</td>
<td>5,520</td>
<td>86.7</td>
<td>40.2</td>
</tr>
<tr>
<td>Hourly wage / share of labor compensation</td>
<td>5,520</td>
<td>29.0</td>
<td>55.5</td>
</tr>
<tr>
<td>$11 per hour (50% of baseline)</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>$22 per hour (baseline)</td>
<td>5,520</td>
<td>86.1</td>
<td>32.9</td>
</tr>
<tr>
<td>$33 per hour (150% of baseline)</td>
<td>5,520</td>
<td>86.1</td>
<td>32.9</td>
</tr>
<tr>
<td>Magnitude of hiring/firing costs</td>
<td>5,520</td>
<td>53.1</td>
<td>0.2</td>
</tr>
<tr>
<td>No cost</td>
<td>5,520</td>
<td>58.0</td>
<td>55.7</td>
</tr>
<tr>
<td>Baseline level</td>
<td>5,520</td>
<td>58.0</td>
<td>55.7</td>
</tr>
<tr>
<td>200% of baseline level</td>
<td>5,520</td>
<td>58.0</td>
<td>55.7</td>
</tr>
<tr>
<td>Magnitude of new spending*</td>
<td>5,520</td>
<td>51.4</td>
<td>100</td>
</tr>
<tr>
<td>$50,000</td>
<td>50</td>
<td>51.4</td>
<td>100</td>
</tr>
<tr>
<td>$100,000</td>
<td>100</td>
<td>51.5</td>
<td>93.2</td>
</tr>
<tr>
<td>$1 million</td>
<td>1,000</td>
<td>52.5</td>
<td>73.5</td>
</tr>
<tr>
<td>$2.5 million</td>
<td>2,500</td>
<td>54.3</td>
<td>57.5</td>
</tr>
<tr>
<td>$5.52 million (baseline)</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>$7.5 million</td>
<td>7,500</td>
<td>59.8</td>
<td>33.5</td>
</tr>
<tr>
<td>Number of quarters of high spending</td>
<td>5,520</td>
<td>115.1</td>
<td>35.9</td>
</tr>
<tr>
<td>1 quarter</td>
<td>5,520</td>
<td>80.9</td>
<td>46.4</td>
</tr>
<tr>
<td>2 quarters</td>
<td>5,520</td>
<td>65.0</td>
<td>47.5</td>
</tr>
<tr>
<td>4 quarters</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>8 quarters (Baseline)</td>
<td>5,520</td>
<td>55.5</td>
<td>34.3</td>
</tr>
<tr>
<td>12 quarters</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>Uncertainty in government spending</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>No uncertainty (baseline)</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>5,520</td>
<td>57.8</td>
<td>40.1</td>
</tr>
</tbody>
</table>

Note: Labor spending on new employees, and thus the wage bill above, includes hiring/firing costs. Also, total new job-years created is calculated as \( \frac{1}{t} \sum_{t=0}^{\infty} (\epsilon_t - \epsilon_0) \) and gives a measure of total new employment at an annual frequency.
(or labor spending) dollars.

3.4 Policy Implications

Our model sheds light on both what types of sectors to target with government spending and how to structure government spending to attain the greatest amount of employment per dollar of spending. Note that this minimizing cost per job may not be equivalent to maximizing welfare.

Best Sectors to Target

Recall that a significant fraction of the revenue generated as a result of increased government spending accrues to nonlabor factor inputs. Of the dollars used to compensate labor, only a fraction is used to hire new workers. As a result, the best sectors to target include those in which a large fraction of sales revenue is paid to labor as well as those whose hiring/firing costs are low enough that firms in the sector primarily adjust along the extensive margin.

In Table 7, we report the impact of a government spending shock as the number of employees at a firm increases. Holding the total revenue from sales in the steady state constant, as the number of employees increases, a larger fraction of the total steady-state-sales revenue goes toward compensating labor. In our baseline calibration, the total compensation for labor at $2 million was approximately 30% of total sales. For our counterfactual cases, with 87 and 261 workers the labor compensation is approximately 15% and 45% of total sales, respectively. As the fraction of labor compensation rises, the fraction of new government spending that goes toward compensating labor also increases. This, in turn, causes more money to be spent hiring new workers, thereby lowering the dollar cost of each additional job. For our counterfactual exercise holding the government spending shock constant at the baseline calibration, the cost of a new job-year falls three fold, from roughly $296,000 to $99,000, as the fraction of labor compensation at the firm level rises from 15% to 45% of sales. This result indicates that if the government’s goal is to increase employment then it should target firms and sectors that are labor intensive – firms and sectors where most of the sales revenue goes toward compensating labor.

There is an important caveat to the result above. If the increase in revenue going toward compensating labor results from higher wages, as opposed to larger employment, then the effects of government spending are not as large. For example, as the wage increases from $11 to $33 per hour, similar to the previous exercise, the labor compensation goes from 15% to 45% of sales. However, as seen in Table 7, the effects on employment are smaller. The reason is that the per employee cost increases when wage increases. As a result, with higher wages, even though a higher fraction of sales revenue goes toward compensating labor, causing more of the new government spending to go toward compensating labor, the higher cost of labor causes the new government spending to rise more than the labor compensation.

For all the counterfactual exercises in this section we recalibrate the values of $L$, $w_0$, $w_1$, $G$, $T$, and $\gamma_G$. For example, in the exercises below involving a change in the wage rate, after setting the new wage rate we recalibrate the model to the baseline data moments but now with a counterfactual wage rate.
generate relatively fewer new jobs. This observation, coupled with the previous one, indicates that if the government’s goal is to increase employment, then it should target firms with a large number of employees who are earning a relatively low hourly wage.

Next, in the Magnitude of hiring/firing costs rows in Table 7 we report how the cost per job-year changes as the magnitude of the hiring/firing costs changes in response to the baseline shock. Note that as the magnitude of the hiring/firing cost increases, less and less of the new labor spending goes toward hiring new workers. This in turn causes the cost per-job year in terms of wage bill dollars, and thus also government spending dollars, to rise. Our results suggest that government spending should target sectors where hiring/firing costs are low because lower costs will lead to greater adjustment by firms along the extensive margin.

**Structure of Government Spending Shock**

Next, we discuss how the structure of the shock – specifically the size, length, and whether the shock is random or deterministic – has important implications for government job creation.

We first vary the size of the spending shock. As seen in Table 7, when government spending increases by only $50,000 for the firm, no new jobs are created. At $100,000 additional government spending for the firm new jobs are created but at a very high cost of over $1.35 million per job-year. As the magnitude of the spending shock increases to $7.5 million, the cost of a new job falls to $133,000 per job-year. The reason for this large difference in moving from a small to large magnitude shock is twofold.

First, the hiring/firing cost functions are not differentiable when $|e_t - e_{t-1}| = 0$. At this point, the marginal cost of an infinitesimal change in employment is infinity. This introduces nonlinearities into the firm’s hiring/firing decision. Figure 2 illustrates these nonlinearities. Similar to a model with non-convex fixed costs, non-differentiable hiring/firing costs result in the firm having an $(S,s)$ decision rule with an inaction region. As seen in figure for small deviations from the long-run optimal employment level, $e^*$, the firm does not adjust its employment level. For such small deviations, the firm only adjusts the hours of existing workers. In our model, relatively small government spending shocks result in the firm deviating very little from its long-run optimal level. As a result, for small shocks the firm mostly remains in between the $(S,s)$ bounds – the in-action region – thus exhibiting little to no adjustment in the total number of employees.

Second, the level of employment exhibits diminishing returns in the production function. Consequently, as the size of the spending shock rises, the optimal level of employment increases at an increasing rate. Holding the level of labor hours per employee constant and doubling the firm’s output would require the firm to hire $2^{1/\alpha} (> 2)$ as many workers. Therefore, the increase in the number of workers as the spending shock increases is also convex, causing the cost per new job to fall.

In sum, as the magnitude of the spending shock increases, the per dollar effects on employment increase at an increasing rate. This suggests that, if the aim is to create the maximum number of
Figure 2: Policy Function
new jobs, then government spending should be targeted to a small number of firms instead of spreading government spending across many recipient firms.

Table 7 shows how the number of new job-years created varies as the duration of the government spending shock changes. In each case, the total spending over the duration is constant at $5.52 million. The number of new jobs created first falls and then rises as the duration of the shock increases. The reason for this quadratic response is best illustrated by Figure 3. When the government spending shock is short and sharp, the hiring costs play a smaller role and the firm almost fully adjusts (see panels (d)). This results in a large increase in employment with shocks of a short duration.

In contrast, when the government spending is spread over a medium to long duration the hiring costs do matter. In particular, the presence of stochastic hiring costs means that the longer the duration of the shock, the higher the probability the firm draws a low hiring cost and adjusts along the employment margin. Consequently, compared with medium-duration shocks, long duration shocks generate more new job-years.

Our results thus argue in favor of government spending shocks to be of either longer durations or short and sharp. There are merits to both policies. As seen in panel (b) of Figure 3, shorter-duration shocks have a larger peak employment response than longer-duration shocks. Therefore, if the government’s goal is a large short-run employment boost then it should concentrate spending in a few quarters. If the government’s goal is sustained long-term high employment, then a longer-duration shock is preferable.

Finally, we study how uncertainty about the government policy affects the cost per job-year. To add uncertainty we replace equation (3.7) and (3.8) with

$$
\mathcal{C}_G(e_t-1; \psi_t, \tau, G_t) = \begin{cases} 
\min_{e_t} \left\{ C(e_t, e_{t-1}, h_t; \psi_t) + \beta E[\mathcal{C}_G(e_{t+1}; \psi_{t+1}, \tau - 1, G_{t+1})] \right\} & \text{if } \tau > 0 \\
\mathcal{C}_N(e_t; \psi_t) & \text{if } \tau = 0
\end{cases}
$$

(3.9)

s.t.

$$
G_t + \mathcal{P} = (e_t h_t)^\alpha L^{1-\alpha}
$$

(3.10)

and add the following equation:

$$
G_t = \begin{cases} 
0.75(1 + \gamma G)G & \text{with prob. } \frac{1}{3} \\
(1 + \gamma G)G & \text{with prob. } \frac{1}{3} \\
1.25(1 + \gamma G)G & \text{with prob. } \frac{1}{3}
\end{cases}
$$

(3.11)

In this new formulation of the model, once the government shock arrives, there is uncertainty about the magnitude of the government spending level, $G_t$. 

25
Figure 3: Impulse Responses to Government Spending Shock (Different Time Lengths)
To be consistent with our baseline exercises we assume that before period 1 the level of government spending was at its steady-state level, and thus the firm’s value function is still denoted by $C_N$. We then assume that in period 1 there is an increase in government spending with the firm’s value function denoted by $C_G$ and $G_t = (1 + \gamma G)G$. In each of the subsequent seven periods (periods 2-7) the government spending takes on a value of $0.75(1 + \gamma G)G$, $(1 + \gamma G)G$, or $1.25(1 + \gamma G)G$ with 1/3 probability each. Finally, as in the baseline model, we assume that in period 9, government spending returns to its steady-state level and remains there with certainty.

Figure 4 plots the impulse responses for a simulation where the government spending shock, identical to the baseline calibration, has a realized value of $(1 + \gamma G)G$ for each of the eight quarters of the shock. As seen in panel (d), in the presence of uncertainty the firm is less likely to adjust along the employment margin compared with the baseline case, but when it does adjust it hires many more workers. On average this results in a higher cumulative employment and lower cost per employee. The reason the firm hires more employees relates back to the fact that the level of employment exhibits diminishing returns in the production function, causing the optimal employment level to be convex in the size of the government spending. Consequently, per Jensen’s inequality, when uncertainty about government spending increases, the optimal expected level of future employment needed also increases.$^{17}$

Mathematically, if the optimal level of employment is $e^*$ for $(1 + \gamma G)G$, $e^*_L$ for $0.75(1 + \gamma G)G$, and $e^*_H$ for $1.25(1 + \gamma G)G$, then we know that because of diminishing returns, $e^*_H - e^* > e^* - e^*_L$. In turn, the expected optimal employment level next period if each of $0.75(1 + \gamma G)G$, $(1 + \gamma G)G$, and $1.25(1 + \gamma G)G$ is expected to occur with 1/3 probability is $\frac{e^*_H + e^* + e^*_L}{3} > e^*$.

In summary, the model advocates that to generate the maximum amount of employment the government should consider introducing some uncertainty about the magnitude of the government spending shock, especially the chance that the magnitude may be higher in the future.

4 Qualitative Evidence

As demonstrated in the previous section, firms can have incentives to meet the additional demand from government purchases by having existing employees work additional hours. The increase in hours implies that a portion of Recovery Act dollars was spent but resulted in no additional workers hired; moreover, the cost of these additional hours is intensified if these workers are paid an overtime premium.

Dupor (2014) describes a novel component of the recipient reports used in Section 2. In that component, the survey responses contain qualitative descriptions of each project. The responses give hundreds of examples of projects being implemented by using, at least in part, overtime workers. These include industries outside highway construction. For example, a $26,000 grant

$^{17}$This result is often referred to as the Oi (1961), Hartman (1972), and Abel (1983) effect.
Figure 4: Impulse Responses to Government Spending Shock (Uncertainty)

(a) Government Spending
(b) Employment
(c) Hours per Employee
(d) Probability of Hiring/Firing
(e) Cumulative New Jobs/Year (Due to Government Spending)
to a Wisconsin Native American tribe administered by the Department of Justice explains that during 2011:Q1: “This grant does not pay for additional jobs. It pays for overtime for the existing staff for community activities.” As a second example, a portion of a Recovery Act Department of Justice grant awarded to the town of Barnsdall, Oklahoma, during 2011:Q1, was described as follows: “Jobs created were in the form of overtime paid to officers to work on specific quality of life activities.” A grant to the Lyon County (Nevada) sheriff’s office, according to the recipient’s report, had the following impact: “No jobs were created. Overtime was allotted for deputies to perform other duties.” One recipient report from the city of Uniontown, Pennsylvania, stated simply that the labor demand impact of its grant was “payment of overtime for police officers.”

The survey responses also contain many examples of Recovery Act grants being used for small increases in hours worked by existing employees, although they are not referred to explicitly as overtime work. For example, in a National Institute of Health’s grant to Emory University, aid was used to cover 10%-15% of the effort by each of three faculty investigators, and 10%-18% of the effort of a data analyst, a technical assistant, and a training specialist. Two other Ph.Ds each expended 2% of their overall time on the project. Next, a trucking company working on a U.S. Forest Service contract reported that “Existing employees were utilized, but we were able to increase their hours of earnings per week.” Along those same lines, another report stated: “We used our current workforce. This project did not create new positions nor were any existing employees retained due to the Recovery Act funded project.”

In addition, the survey responses show that a portion of Recovery Act dollars was used for increased wage rates of existing workers. During 2011:Q1, a $43,700 grant to a Pennsylvania Child Welfare Services center as part of a Head Start program was used in part to “Increase the compensation and benefits of staff through a 1.84% cost of living adjustment to improve the overall quality of the program.” As another example, one part of a grant to the Puerto Rico Department of the Family was used to “to provide salary retention incentives” to employees. Another Head Start grant was, in part, described as follows: “Salaries were enhanced to ensure greater job satisfaction and staff retention.” Hundreds of Head Start programs across the United States used Recovery Act grants, in part, to fund similar cost-of-living increases.

In addition to wage increases for existing workers, the survey responses showed that Recovery Act dollars were used to fund pensions. As an example, one grant recipient described “quality improvement funds used to increase qualified Head Start and Early Head Start staff fringe benefits, specifically 403B Pension contributions.” Another recipient report stated that “A portion of the funding was used to cover a portion of the pension and health benefit costs for specific staff members identified in this area.”

Increased payments to pensions likely led to little or no new job creation. Pension funding may be of an additional Ricardian-equivalence type. Specifically, the federal government borrowed to fund the dollars that financed these Recovery Act programs, but pension financing effectively undid
the borrowing by increasing private (albeit forced) savings.

The survey evidence described above lends qualitative evidence supporting the mechanism hypothesized early in the paper. Note that other reports give descriptions of job creation and retention at the extensive margin. We do not provide examples of these descriptions because the extensive margin effect has already been highlighted in existing work.

5 Conclusion

This paper makes five contributions. First, it introduces a new dataset. The data consist of a quarterly panel of zip-code-level spending, which constituted $250 billion of the 2009 Recovery Act. The dataset should allow future researchers to analyze the effects of the Recovery Act at a much finer level of disaggregation than previously considered.

Second, the paper uses this dataset along with an instrumental variables approach to estimate the effect of Recovery Act spending on employment. The results confirm previous findings that the Act may have created and saved jobs; however, this change came at a very high cost. Also, for some specifications, the spending had no statistically significant effect on employment.

Third, the paper analyzes the effect of Recovery Act spending on the wage bill. In medium sized counties, we found that each $100 of spending resulted in approximately $38 of wages to workers (including both existing and new employees) in that local county. Moreover, we found that roughly $18 of these wages went to previously employed workers rather than new hires or saved workers. Stated another way, the stimulus had a substantial effect on either the hours worked and/or the wage rate paid to existing workers. The additional payments to existing workers might help explain why the cost of job creation at the extensive margin was so high.

Fourth, the paper builds and calibrates a structural model of a firm capable of explaining our instrumental variable estimates. By its nature, the instrumental variables approach is limited in its ability to analyze the microeconomic mechanisms underlying our findings. By building a structural model as well, and in light of, our empirical findings, we can better understand the underlying economic mechanism.

Fifth, we use the paper’s structural model to conduct counterfactual policy simulations. These simulations provide insight into both which sectors to target and how to structure government spending shocks so as to achieve a lower cost of job creation.
References


### Table A.1: Agencies and subagencies administering Recovery Act funds, inclusion or exclusion for this paper’s dataset.

<table>
<thead>
<tr>
<th>Included in Dataset</th>
<th>Excluded in Dataset</th>
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<tbody>
<tr>
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<td>Federal Communications Commission</td>
</tr>
<tr>
<td>Army Corp of Engineers</td>
<td>Government Services Administration</td>
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<tr>
<td>Commerce, Dept. of</td>
<td>Labor, Dept. of</td>
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<tr>
<td>Corporation for National and Community Service</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>Defense, Dept. of</td>
<td>Small Business Administration</td>
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<tr>
<td>Education, Dept. of</td>
<td>Social Security Administration</td>
</tr>
<tr>
<td>Energy, Dept. of</td>
<td>State, Dept. of</td>
</tr>
<tr>
<td>Environmental Protection Agency</td>
<td>Railroad Retirement Board</td>
</tr>
<tr>
<td>Health and Human Services*, Dept. of</td>
<td>Interior, Dept. of</td>
</tr>
<tr>
<td>Housing and Urban Development, Dept. of</td>
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<tr>
<td>Transportation, Dept. of</td>
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<tr>
<td>Treasury, Dept. of</td>
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</tbody>
</table>

Notes: (*) The emergency Medicaid state grants component of Department of Health and Human Services Recovery Act funds are excluded from the data set because they are not also available in the recipient reports.

## A Appendix

### A.1 The Data

The following agencies and subagencies were responsible for administering Recovery Act funds.

The Department of Labor funds are excluded because these consist primarily of direct transfers to individuals (through unemployment insurance benefits) and are not subject to recipient reporting. The emergency Medicaid grant component of the Department of Health and Human Services Recovery Act funds are likewise excluded from the data. The Social Security Administration funds are excluded because these consist primarily of direct transfers to individuals (entitled “economic recovery payments”) and are not subject to recipient reporting.

The remaining excluded agencies make up a very small fraction of Recovery Act dollars. For nearly every agency, its reports showed that all or almost no funds were channeled through the states.

### A.2 Solution Method for Firm Problem

We use function iteration on a grid to solve for the function $\mathcal{C}(e, G, \psi)$ given by equation (3.5). The grid has 501 points in the $e$ dimension and 101 points in the $\psi$ dimension. The points in the $G$ dimension depend on the value of $T$. For the baseline calibration, $T = 8$ and thus the function has 9 points in the $G$ dimension: one each for the 9 different states of the economy in the $G$ dimensions.
(i.e., one for \( t \not\in [1, T] \) and one each for \( t \in [1, T] \)). The expectations operator on the right-hand side of (3.5) is solved by discretizing the uniform distribution over the 101 points in the \( \psi \) dimension.

Once we have \( \mathcal{E}(e, G, \psi) \), we use it to construct a policy function \( e_{t+1}(e_t, G_t, \psi_t) \). This policy function along with the exogenous processes for \( G \) and \( \psi \) fully describe the evolution of the state vector, \( (e_t, G_t, \psi_t) \), for the firm. We can then use the state vectors along with equations (3.6) and (3.3) to determine the number of hours each employee works, \( h_t \), the per employee wage, \( w(h_t) \), and whether the firm adjusts the number of employees for each period of our simulation.

For the results in Table 7 and the impulse responses, we simulate our model economy 30,000 times over different realizations of \( \{\psi_t\}_{t=0}^{\infty} \). In this way, our final results yield the expected response of the firm over the stochastic variable \( \psi_t \). An alternative way to interpret our results is that they give the response of an average firm in an economy with 30,000 identical firms.