The Employment Effects of Levee Investments

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Abstract

This paper examines the causal impact of the levee investment projects under the American Recovery and Reinvestment Act (ARRA) of 2009 on employment at the county level. To address endogeneity, I use a new instrument: the length of levees. As the length of levees is a persistent stock variable and is unrelated to the magnitude of the recession, it constitutes an ideal instrument to measure the effect of levee projects. I find that a county's receipt of a marginal $100,000 investment in levees resulted in an additional 4.2 job-years, 1.8 of which were in the construction sector. I also find that the projects showed short implementation lags and seasonal cycles in employment gains.

Keywords— Fiscal policy; Infrastructure; Natural disasters.

JEL codes— E24, E62, H54, H72, H76, H54, Q54

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1 Introduction

Infrastructure can play an important role in increasing long-run output and standards of living. In the short run, infrastructure investment is used to stimulate local labor markets. Despite its widespread use, researchers and policymakers debate whether infrastructure investment constitutes an effective tool in counter-cyclical fiscal policy. Ramey (2020) points out that there is scant empirical evidence that infrastructure investment has a short-run stimulus effect. While there are many types of infrastructure, recent studies have primarily focused on highway construction. The employment effects of infrastructure are likely to be heterogeneous because of differences in government contracting processes, the size of businesses targeted, and the type of location targeted. Moreover, while previous literature has evaluated employment multipliers and implementation lags in infrastructure stimulus programs, evidence of seasonal cycles is still scarce. Tschetter and Lukasiewicz (1983) and Geremew and Gourio (2018) point out that seasonality is a well-known characteristic of the construction industry, which is a primary target sector for infrastructure investment. To design a counter-cyclical fiscal infrastructure policy, such evidence would be essential.

This paper examines the impact of the levee investment projects under the American Recovery and Reinvestment Act (ARRA) of 2009 on local labor markets, focusing on the following factors: (1) employment multipliers, (2) implementation lags, and (3) seasonal cycles. I use levee projects to examine the employment effects of the ARRA for three reasons. First, levee projects have a different institutional design to highway projects. Previous empirical analyses (Wilson, 2012; Conley and Dupor, 2013; Leduc and Wilson, 2013, 2017) have exploited formula-based mechanisms to examine the effects of highway projects. Unlike highways, the majority of federal funds for levees are not distributed by a formula to states or through competitive grant programs (Carter, 2018). Second, the transaction amount per levee project is likely to be small. While the mean transaction amount in highway projects is \$2.1 million, in levee projects this amount is \$1.2 million. This means that levee projects may target smaller businesses. Third, levee construction is likely to be seasonal. For example, it may be difficult to construct levees when the water level is high. Such difficulties may lead to implementation lags and seasonal cycles. Therefore, these three differences between levee and highway projects provide new interpretations of fiscal multiplier.

The main challenge in obtaining accurate results is that the amount of investment a county receives depends on the county's economic conditions. Policymakers deliberately selected infrastructure projects that would result in immediate employment. Thus, one may expect that counties with severe economic conditions (e.g., a high unemployment rate) received more investment compared to counties with less severe economic conditions. If so, the OLS relationship between investment and changes in employment ratio understates the true effect of levee investment. To address this concern, one approach is to use instrumental variables regression. Previous literature on highway investment has used pre-recession formulas as an instrumental variable to eliminate endogenous problems related to highway funding. These formulas include pre-recession total lane miles of federal highway, total vehicle miles traveled on federal highways, tax payments paid into the federal highway trust fund, and Federal Highway Administration obligation limitations. Since policymakers for levees do not use formulas for the distribution of funds, it is not possible to use formula-based approaches as an instrument to evaluate levee projects.

To insure against the concern that the apportionment of grants may be correlated with pre-existing labor market outcomes, I use an instrumental variable to isolate the component of the investment unrelated to changes in economic circumstances. In particular, I address this endogeneity problem by exploiting the length of levees from the National Levee Database (NLD). The NLD provides the exact locations of levees in the U.S. Levee length is necessarily correlated with investment but uncorrelated with economic conditions. County-level levee length is correlated with investment because governments must maintain these levees. On the other hand, the length of levees is not correlated with short-run fluctuations in economic circumstances. These assumptions allow me to use the length variable as an ideal instrument for local investments.

There are three main findings. First, the levee investment projects had a positive effect on employment. My dynamic specification shows that the positive effects continued until the end of the program. The instrumental variable (IV) estimates imply that an additional investment of $100,000 led to a gain of 4.2 job years in total employment, of which 1.8 were in the construction sector. This point estimate corresponds with a cost per job of $24,000 for total employment and $55,000 for the construction sector. There are a number of recent academic studies analyzing the effect of ARRA spending on employment. Chodorow-Reich (2019) summarizes empirical cross-sectional multipliers, comparing recent empirical studies in this field. He finds that the 90 percent confidence interval for the "cost-per job" is ($25,500, $73,900). While his estimates are based on cross-state regressions, my estimates use cross-county regressions. Though the difference of approaches may yield different results, levee projects may be a particularly low-cost means to support employment during a recession.

Second, the projects had short implementation lags. Policymakers and researchers may be concerned that the implementation of the program might show a lag between the date that budget plans were approved and the timing of the positive employment effects. Typical infrastructure projects might cause implementation lags for a number of reasons. For example, construction companies need to bid to be awarded a project. After they win the bid, they must survey local geological conditions and borrow areas for the project. Although such processes take time, they do not require many workers. Following this, construction companies can start major construction work and hire many workers. However, in this study levee projects had immediate effects on employment. This finding alleviates common concerns about the implementation lags of levee projects, suggesting that levee projects are an efficient way to create employment effects quickly.

Finally, the findings take seasonal cycles into account. Seasonality is a well-known characteristic of the construction industry. While constructing highways in the summer is suitable, building levees in the summer would be challenging because the higher water level disturbs safe and efficient construction conditions. I find that the estimates for winter are relatively large and statistically different from zero in terms of both total employment and construction employment. Moreover, the estimate for winter in the construction sector is statistically different to those for autumn and summer. This means that seasonal factors should be considered in levee construction. My result suggests that the seasonal cycle is an important characteristic to consider in the design of a public stimulus package related to infrastructure projects.

As a robustness check, I perform two falsification tests to assess whether the instrument satisfies the exclusion restriction—that is, that the instrument is not correlated with the error term in the equation of interest. The first test is a reduced-form regression, using data from between January 2000 and August 2009. This IV strategy rests on the assumption that levee investment is the only channel through which the length of levees affects employment outcomes. If this assumption is correct, then a positive relationship between the length of levees and employment outcomes should not exist before the commencement of levee investment. There is little evidence that in the years before the ARRA was passed, counties experienced systematically different employment trends. The second test is using an observable variable, housing prices, as a proxy for unobservables, such as geographic conditions, to check the correlation between the instrument and unobservables. There is a possibility that levee length may be correlated with other unobservables. If this were the case, the correlation would violate the exclusion restriction. There is little evidence that the instrument is correlated with the housing price data proxy. The results of these falsification tests strengthen the case that the IV estimates in this study reflect the causal impact of the ARRA investment on subsequent employment change, rather than a spurious correlation due to omitted factors.

I provide two extensions of the baseline results. First, I check the heterogeneity of the effect of levee projects. I divide counties into two subgroups by using the median population and apply a regression analysis to each subgroup. I find that the estimate in smaller counties for construction employment is positive and statistically significant. This result suggests that it may be more effective to focus on investment in smaller counties. Second, I provide the effect of levee projects on high school completion. A model of human capital predicts that an increase in the wages of workers with low education relative to wages of workers with high education will reduce investment in schooling because the returns of additional years of schooling are diminished. I find little evidence that this infrastructure investment affects high school completion rates.

My analysis contributes to growing empirical literature that studies local economies in order to estimate fiscal multipliers, investigating cross-state or cross-county variations in government spending. This paper is the first, to my knowledge, to explore the cross-county variation in levee investment to estimate its employment effects by using month-level data. A number of papers have estimated the combined effects of the different stimulus measures (e.g., transfers to individuals, financing of public employment, and infrastructure investments) included in the ARRA (Feyrer and Sacerdote, 2011; Chodorow-Reich et al., 2012; Wilson, 2012; Conley and Dupor, 2013). While meaningful cross-sectional variation in spending is confined to the state level because of a lack of identifying variation in the data, some studies have examined the employment effects of investment with county-level data (Dupor and Mehkari, 2016; Dupor and McCrory, 2017; Dube et al., 2018; Garin, 2019; Popp et al., 2020). Chodorow-Reich (2019) and Ramey (2020) survey this literature in detail. The most closely related work to this study is that of Garin (2019). I use a new instrumental variable to examine the effect of levee projects, while Garin (2019) uses a difference-in-difference approach to analyze highway projects. Moreover, while he examines the yearly effects on employment, I examine monthly effects on employment to evaluate detailed implementation lags and seasonal cycles in the short run.

The remainder of this paper proceeds as follows. In Section 2, I provide background information about the ARRA stimulus package. Section 3 describes data sources. Section 4 contains the econometric methodology and identification strategy for the instrumental variable. Section 5 presents and discusses the results. Section 6 provides analyses of robustness and extensions. Section 7 offers some concluding remarks.

2 Background

The financial crisis between 2007 and 2009 caused a recession (the Great Recession) in the U.S. and world economies. The crisis began on Wall Street, pushing the U.S. economy into recession in December 2007. From a low of 4.4% in March of that year, the unemployment rate rose steadily, peaking at 10.0% in October 2009. The employment-population ratio dropped from 63% in 2007 to 58% in 2009, a loss of 8.6 million jobs. At the bottom of the recession, real GDP was more than 7% below potential. Some local areas experienced more Great Recession shocks than other local areas. For example, local areas that had previously experienced housing booms were disproportionately affected (Mian and Sufi, 2014).

After this rapid decline in economic activity, the United States Congress passed the ARRA on January 6, 2009. On February 17, 2009, President Obama signed into law the ARRA, a $787 billion package designed to stimulate aggregate demand in the economy. The final plan included more than $250 billion in tax cuts and more than $500 billion in new government spending on such things as unemployment benefits, infrastructure, education, health care, and aid to state and local governments. According to the Congressional Budget Office, about $185 billion of the stimulus was disbursed in 2009, followed by another $400 billion in 2010. There were two main purposes for this law: the first one was to save or create at least three million jobs by the end of 2010 (Romer and Bernstein, 2009), and the second was to invest in transportation, environmental protection, and other infrastructure that would provide long-term economic benefits. Proponents of the Recovery Act emphasized the bill's supplemental funding for "shovel-ready" infrastructure projects, or construction work that could begin immediately once funded. Increasing labor demand in the construction sector was a priority, as the housing bust precipitating the recession had particularly affected construction-sector spending and employment.

The ARRA provided funding to the U.S. Army Corps of Engineers (USACE) to accomplish these goals through the improvement of water-related infrastructure. The legislation appropriated $4.6 billion to USACE for a program known as Civil Works projects. Civil Works projects utilized several kinds of accounts. For example, $2 billion was allocated for the construction account and $2.075 billion was provided for the operation and maintenance account. The Mississippi River and Tributaries account received $375 million in appropriations. USACE identified many potential Civil Works projects that met the criteria of the legislation for funding. Selected projects were distributed across the U.S. and across USACE programs to provide the nation with inland and coastal navigation, environmental, flood risk management, hydropower, and recreational resources. This paper focuses on levee projects because the institutional design underlying the geographical distribution of levees helps to identify shocks to county-level investment.

USACE is directly engaged in planning and construction projects, with the agency's appropriations used to perform work on geographically specific projects. Additionally, the ARRA announced project selection criteria for projects that would: (1) be obligated/executed quickly; (2) result in high and immediate employment; (3) have little schedule risk; (4) be executed by contract or direct hire of temporary labor; and (5) complete a project phase, complete a project, or provide a useful service that did not require additional funding. The second and fourth factors raise concerns over endogeneity, motivating the instrumental variable approach.

According to USACE (2010), spending plans were approved on August 19, 2009. Therefore, the data points used for analysis were from August 2009 onwards. Although the estimates evolve over time (see Section 5), the estimates of changes between August 2009 and February 2010 are reported as a baseline result because February 2010 was one year after the ARRA was enacted. The program was expected to finish by September 30, 2011. My primary outcome data source, the Quarterly Census of Employment and Wages (QCEW), provides monthly employment data on the 12th day of the month. The final data point used for analysis was October 2011.

3 Data

Baseline Setting.— The main analysis is based on counties with levee projects related to the ARRA. Since the ARRA does not require reports of trade less than $25,000 and the focus of this study is the intensive margin of the labor demand, I exclude counties with less than $25,000 outlays. The main drawback to limiting the data is that my sample size is small, so I also report results from all counties in the next section. I normalize variables by working-age population (between 15 and 65 years of age) from the dataset of the Survey of Epidemiology and End Results for three reasons. First, levee projects in populated areas are likely to have increased costs. For example, the wages for construction workers and the cost of renting land for projects in populated areas would be higher than in rural areas. Additionally, it likely takes more time to come to a consensus in projects in populated areas, leading to higher costs (e.g., the rent cost of construction machines). To control for these effects, I use normalization. Second, when I regress the change of employment on the level of government investment, my instrument is weak, which may lead to biased results. Third, previous literature on empirical cross-sectional multipliers (e.g., Chodorow-Reich, 2019) typically uses normalization.

Outcome Variable.— My primary outcome variable is the change in private-sector employment, normalized by working-age population. I obtained monthly county-by-sector employment totals from the Quarterly Census of Employment and Wages (QCEW), a product of the Bureau of Labor Statistics (BLS). The QCEW data is compiled from administrative establishment-level records collected by state unemployment insurance systems. The resulting dataset includes monthly average employment (full-time and part-time) and salary levels, broken down by county and industry. Infrastructure projects may affect economic activity in other industries. On the one hand, it is possible that an increase in production in the construction industry boosts local demand for intermediate goods and services (i.e., purchasing construction materials). On the other hand, the addition of jobs in the construction sector may crowd out jobs in other industries. I select industries related to construction, including Mining, Manufacturing, Wholesale Trade, Finance and Insurance, and Other services, and define the sum of these industries as total employment.[1] I analyze the effect of levee projects on employment in terms of both (1) total employment and (2) employment in the construction industry.

Endogenous Variable.— My primary endogenous variable is the county-level levee investment, normalized by working-age population. I identify levee projects and locations using reports through Recovery.gov.[2] I retrieved data from FedSpending.org, selected the "Department of Defense" category, and filtered by "U.S. Army Corps of Engineers - civil program financing only". There are many types of Civil Works projects, including navigation, environmental, and recreational programs. To select only levee projects, I used keywords in the description of each project. First, I selected projects that had keywords such as "flood", "dike", "pump", and "levee". Second, since the first selection process was not sufficiently narrow to select only levee projects, I excluded projects with keywords such as "dam", "port", "lock", and "harbor".[3] Although the dataset does not include county name, I pinpointed the counties in which these projects were located by using "Place of

[1] Carrington (1996) focuses on the short-run multiplier generated by the construction of the Trans-Alaskan Pipeline System. He finds evidence that the increase in construction jobs caused by the System had significant multipliers for jobs in other parts of the sector in Alaska.

[2] This website is no longer available, but archived data are available at `http://data.nber.org/data/ARRA/` and `https://www.fedspending.org/rcv/index.php?reptype=a`.

[3] All keywords to select levee projects were "flood", "levee", "river", "pump", "revetment", "floodway", "dike", "bank", "seepage", "improvement", "excavation", "dredg*", "maintenance", "well", "inspection", "stabilization", "spillway", and "erosion". The keywords excluding other kinds of projects were "dam", "port", "bay", "lock", "harbor", "reservoir", "navigation", "lake", "jetty", "gulf", "traffic", "waterway", "inland", "ship", "boat", "vessel", "water", "savannah", "garrison", "Atlantic", "canaveral", "treatment", "sewer", "pipe", "alaska", "Hawaii", "erie", "Galveston", "jacksonville", "intracoastal", "environmental", "restoration", "roof", "herbicide", "Saugatuck", "clinical", "channel", "picnic", "keys", "street", "park", "road", "grounds", "irrigation", "aquatic", "wetland", "recreational", "tractor", "hospital", "building", "vehicle", "estuary", "oxygen", "tuckahoe", "storage", "museum", and "willamette".

Performance Latitude" and "Place of Performance Longitude". Based on the project locations, I aggregated data at the county level. Although Wilson (2012) uses actual payments reported in weekly Financial and Activity Reports and cumulates the payment to analyze the impact of the investment, most of the literature (e.g., Chodorow-Reich et al., 2012; Leduc and Wilson, 2017) uses total outlays as a one-time shock. I also use levee investment as a one-time shock, because weekly reports are not available at the county level. Given this, the identification of the effect of investment on employment depends on cross-sectional variation in investments across counties. Figure 1 plots the geographical variation in investments, with counties shaded according to investments. It shows that there is ample variation in investments across counties. In particular, investments were focused around (1) the confluence of the Mississippi River and the Ohio River, (2) Louisiana, and (3) Florida.

Instrumental Variable.— The instrumental variable is county-level levee length, normalized by working-age population. This data comes from the National Levee Database (NLD). The NLD is developed by USACE and includes comprehensive information about levees in the U.S. In particular, the database contains levee location, levee length, leveed area, and the year in which each project was completed. The database contains information to facilitate and link activities, such as flood risk communication, levee system evaluation for the National Flood Insurance Program (NFIP), levee system inspections, flood plain management, and risk assessments. There are 9,084 levee systems in the U.S. The NLD provides levee systems data in many formats, including GeoJSON and Shapefiles, a common format for geographical vector data. I downloaded GeoJSON files because QGIS plugins do not work with Shapefiles from the NLD. I restricted the data to the categories "USACE federally constructed and USACE federally operated" and "USACE federally constructed, turned over to public sponsor operations and maintenance". I also restricted systems completed by August 1, 2009, the first day of the month in which the spending plan was approved. This restriction yields 1,246 levee systems. The dataset includes polygon data and inspection data for levees. Unfortunately, this dataset is not available at the county level. To address this issue, I used GIS software (QGIS) plugins, including "dissolve", "intersection", and "measure length" on PyQGIS, to calculate county-level data.

Figure 2 shows the levee systems related to USACE. Blue objects represent the locations of levees. There are two geographical features in this figure. First, counties along the Mississippi River and the Sacramento River have longer levees because the Flood Control Act of 1928 authorized USACE to design and construct projects for flood control on the Mississippi River and its tributaries, as well as the Sacramento River. Second, counties located in southern Florida have levee systems because of the Central and Southern Florida Project in this region. Therefore, the length of levees related to the federal government in these regions is greater than in other regions.

Control Variables.— My baseline specification includes two control variables that may be simultaneously correlated with employment outcomes and levee investment. First, I control for employment level normalized by working-age population, because one would expect the baseline employment level to affect subsequent employment change. In particular, I use the level of employment normalized by working-age population in February 2009, when the ARRA was enacted. As mentioned in the last section, this spending plan was approved in August 2009. I use the employment conditions in February 2009 because this data would have been used by policymakers to make a project list. In fact, lobbyist communication occurred between March 2009 and June 2009. Thus, this employment variable should be correlated with levee investment and employment outcomes. Second, I control for employment trend normalized by working-age population because employment changes are highly persistent. I use the previous year's employment trend, from August 2008 to August 2009.

Table 1 presents summary statistics for the main variables used in the study. The average changes in total employment and construction employment were negative, though there is considerable cross-county variation in this pattern. The average investment was about \$2.3 million and the average length of levees was 31 kilometers per county. These variables also showed considerable variation.

4 Methodology

The goal of the empirical strategy is to assess both the dynamic employment response and the overall employment effect of the investment projects. To this end, I use an instrumental variable approach to estimate investment-induced employment gains. To understand the framework and concerns, I begin with a simple OLS framework that relates levee investment to employment. The change in the ratio of employment in industries to potential workers in a county, c, depends on levee investment that the county receives, a series of controls that capture differential trends, and a county-specific shock:

$$\frac{E_{t,c} - E_{Aug\ 2009,c}}{N_c} = \beta_{0,t} + \beta_{1,t}\frac{G_c}{N_c} + \beta_{2,t}Controls_c + \epsilon_{c,t}, \tag{1}$$

where $E_{t,c}$ is the employment of construction industry in county c in period t, N_c is the number of potential workers in the county c, $\beta_{0,t}$ is national-level shock, G_c is the investment in levees received by county c, $Controls_c$ are county-level controls in the county c, and $\epsilon_{c,t}$ is a county-level mean-zero shock.

If county levee investment per potential worker, $\frac{G_c}{N_c}$, were uncorrelated with the error term, ϵ_c, then Equation 1 could be estimated with bivariate OLS. However, this assumption may not be valid. As mentioned above, the ARRA levee projects depended on five factors: projects needed to (1) be obligated/executed quickly; (2) result in high and immediate employment; (3) have little schedule risk; (4) be executed by contract or direct hire of temporary labor; and (5) complete a project phase, complete a project, or provide a useful service that did not require additional funding. These factors, especially (2) and (4), may be correlated with post-stimulus economic conditions.

For example, to result in high and immediate employment, counties with the most severe economic conditions may have received more investment through USACE compared to counties with less severe economic conditions. If so, the OLS relationship between infrastructure investment and changes in employment ratio would understate the true effect of infrastructure investment.

I address this concern by using an instrument that isolates the component of the investment unrelated to changes in economic circumstances. Specifically, I implement a two-stage least squares estimation, using the length of levees per capita as an instrument to evaluate the ARRA investment. The instrument satisfies the following conditions: (1) instrument relevance and (2) instrument exogeneity. Instrument relevance means that the length of levees is correlated with spending. If a county has a longer levee, the investment should be higher to maintain this physical capital. Instrument exogeneity means that the length of levees is not correlated with the error term of Equation 1. The length of levees is not affected by short-run economic fluctuations. For these reasons, it constitutes an ideal instrument for local investments. I report empirical evidence for these assumptions in the next section.

5 Results

5.1 Relevance and Exclusion Restriction

One main assumption of the IV strategy is that the instrument is relevant; that is, that the length of levees is a predictor of investment. Typically, the relevance of the instrument is tested using the first stage of the IV model. Table 2 shows the results of first-stage regressions. Panel A uses my preferred sample set: counties with positive investment. Panel B uses all counties as a sample. The outcome variable is the investment in levees, normalized by working-age population and measured in \$100,000 increments. The coefficients in Table 2 represent the average increase in investment (in increments of \$100,000) due to one additional kilometer of levees. One additional kilometer of levees is associated with an increase in investment of around \$29,000. That is, counties with longer levees have to spend more to maintain them. The positive coefficients are consistent with this pattern.

Column 1 in Panel A presents a simple bivariate regression. The coefficient for the first instrument (levee length) is 0.29, with a partial F-statistic of 13.41. The coefficient is precisely estimated. Columns 2 to 5 show that this positive and precisely estimated relationship between the instrument and my main endogenous variable is robust to the inclusion of a number of covariates. As argued by Stock and Yogo (2005), we do not need to worry about a weak instrument if the first-stage F-statistic exceeds 10. Since this partial F-statistic is above the conventional critical value of ten, the first stage in Panel A is strong when I use my preferred sample set.

On the other hand, Panel B shows that the instrument becomes weak when all counties are used as a sample, because the robust standard errors become relatively large. While some counties received levee investments, other counties with levees of similar lengths did not. One possible reason is that factors other than the length of levees are considered when policymakers accept the project. The ARRA required that projects be obligated quickly and have little schedule risk. This means that policymakers would have reviewed factors such as the progress of the ground survey for the construction site and the consensus in neighborhoods for the project, both of which are unobservable to researchers. When all counties, including zero investment, are used as the sample, these components affect the residual in the first stage and the F-statistic becomes low.[4]

The second main assumption of the IV strategy is the exclusion restriction, which requires the errors $\epsilon_{c,t}$ to be independent of the instrument. This implies that levees may be correlated with employment outcomes only via their effect on investment. The length of levees in the United States is very persistent over time, and therefore is unlikely to be correlated with economic conditions in the short or medium run. Figure 3 illustrates this persistence by plotting the length of levees in 2009 against the length of levees in 1989. The right-hand graph is normalized by working-age population. The data is tightly clustered around the 45-degree line. This demonstrates that there are at most minor changes in the length of levees over time.

The age distribution of levee systems from the NLD offers another view of this persistence. Figure 4 displays the age distribution of levee systems. The mean is 1967, with the data indicating that the existing stock of levees was constructed during the 1950s and 1970s. The current demand for levees is declining and maintenance costs are increasing. The length of levees is therefore predominantly determined by policy decisions made before the 1970s. This means it is likely that the length of levees is independent of employment outcomes during the recession of 2009.

Section 6 reports further evidence on the exclusion restriction.

5.2 Baseline Results

Table 3 presents baseline results for the effect of levee investment on employment between August 2009 and February 2010. Panel A shows the effect on total employment in construction-related sectors. Panel B presents the effect on employment in the construction sector. Columns 1–3 of Panel A report OLS estimates that show positive effects on the change in employment. Column 3 shows that after controlling for the level and trend of employment, the estimated impact on employment becomes small. Columns 3–6 present the IV results, which yield imprecise but much

[4] Using a dummy variable in Equation 1 provides a different view of this discussion. In particular, consider an analogous version of Equation 1:

$$\frac{E_{t,c} - E_{Aug\ 2009,c}}{N_c} = \beta_{0,t} + \beta_{1,t} T_c + \beta_{2,t} Controls_c + \epsilon_{c,t},$$

where T_c is a dummy variable for whether or not county c has levee investment. When I use the baseline setting in the next subsection, the OLS shows that the coefficient $\beta_{1,t}$ is positive and statistically significant, which means that the existence of a levee project and the subsequent employment growth show a positive correlation.

larger impacts than OLS. The fact that the OLS estimate is lower than the IV estimate suggests that levee investment and economic conditions are negatively correlated: counties experiencing worse economic outcomes were likely to receive more investment. Column 6, the preferred specification, suggests that for every $100,000 in investment per working-age population that a county received, the county's total employment increased by 1.81 per working-age population between August 2009 and February 2010. The next subsection provides further discussion of how to interpret this result.

Panel B in Table 3 uses the change in construction employment as the outcome variable. The OLS coefficients (Columns 1–3) are positive, relatively small in magnitude, and not statistically significant. The IV results (Columns 3–6) suggest a positive and strong relationship between levee investment and change in employment in the construction sector. Column 6, the preferred specification, suggests that for every $100,000 in investment per working-age population, counties' construction employment increased by 0.96 per working-age population from August 2009 to February 2010.

It is also worth mentioning that the estimated coefficients on the control variables relate to employment conditions in the pre-stimulus period. All coefficients are negative. This result suggests that counties with worse initial employment conditions were likely to grow faster. Since employment growth following the stimulus was related to the stimulus package and employment conditions, controlling for pre-employment conditions yields smaller effects of investment on subsequent employment.

Table 4 presents the results of all counties, including zero investment, which is not my preferred sample set. The coefficients are unstable and statistically insignificant.

My preferred specifications suggest that the increase in labor demand from levee investment had positive impacts on the change in employment between August 2009 and February 2010. The coefficients in Panel B of Table 3 have a lower magnitude than those in Panel A of Table 3, suggesting that the "indirect" employment gains in construction-related sectors were notable. To look at this more clearly, I examine employment effects by sector. Table 5 reports the results of estimating the empirical model via IV with the full set of controls and with the six groups of employment by industry as dependent variables. Column 1 shows that the estimate is positive and statistically insignificant. One interpretation consistent with the finding in Column 1 is that jobs in the mining industry include the mining of construction sand. This element is one of the input factors in the production of levees, and the transportation cost of construction sand is high. Thus, levee investment may have led to benefits for the mining industry. Although manufacturing creates pieces of construction machinery, Column 3 shows no evidence that levee investment affected employment in the manufacturing sector. One possible interpretation is that relevant manufacturing companies may not be located in the counties in which projects were undertaken. Columns 4–6 show that this result is very unstable; thus, I find little evidence that investment affected employment in these industries.

To understand the dynamic effects of levee investment on employment, I explore how my estimates evolve as I move toward the month that marks the end of my sample. Specifically, I rerun the cross-sectional regression for changes in employment from August 2009 until every month from September 2009 to October 2011 and report the second-stage coefficients on levee investment from my preferred specification with the full set of control variables. That is, I rerun the estimate from August 2009 to September 2009, August 2009 to October 2009, August 2009 to November 2009, and so on, reporting each of these 26 coefficients.

Figure 5 presents these results for total employment and employment in the construction sector. The solid line represents the point estimate and the dashed lines indicate the 90 percent confidence interval. Three important patterns emerge. First, levee investment results in immediate positive effects on counties' local labor markets, with the effect particularly large after the winter of the second year. Second, the effect on the construction industry is likely to be statistically significant, though the indirect effect is positive but not statistically significant. Third, the construction industry shows a seasonal cycle in which the effect is larger in winter. I discuss these implementation lags and seasonal cycles in the last two subsections.

5.3 Employment Multipliers

My results indicate a positive relationship between investment and relative employment outcomes. To interpret the magnitude of the estimates, I can translate the regression coefficients into the increase in job-years from $100,000 of marginal county investment. This requires two assumptions. First, I assume that investment received up until October 2011 has no employment effects beyond October 2011. If the employment effects remain beyond October 2011, then my estimate of job-years is a lower bound. Second, I assume that investment made after October 2011 do not influence employment changes before October 2011.

Under these assumptions, the increase in job-years from $100,000 of investment can be calculated by taking the integral under the dynamic charts (Figure 5) and dividing this by 12 to convert job-months to job-years (Chodorow-Reich et al., 2012). My point estimates suggest that $100,000 of marginal investment increased county employment by 4.2 job years, 1.8 of which were in the construction sector. While the estimate is not significant in the total employment case, in the construction sector the effect is significant. Dividing $100,000 by 4.2 job-years yields a cost per job of $24,000. Dividing $100,000 by 1.8 job-years yields a cost per job of $55,000. The sum of awarded grants in my sample is 453 million dollars. Thus, this program would have created 19,000 jobs in total, including 8,300 jobs in the construction sector.

In the context of the costs and benefits of fiscal stimulus, levee investment may be a particularly low-cost means of supporting employment during a recession: a cost per job of $24,000 is at the lower end of cost-per-job-year estimates for the ARRA. Chodorow-Reich (2019) reviews empirical studies of fiscal multipliers and provides an updated analysis of the ARRA. He shows that the 90 percent confidence interval for the "cost-per-job" is ($25,500, $73,900). While his estimates are based on cross-state regressions, my estimates use cross-county regressions, and this difference in approaches may yield different results. The magnitude of the employment effect can be interpreted by comparing the estimate of the cost per job year with the wage in construction, the main target industry of the investment program. To do so, I compare my result with the annual wage. In my sample counties, the average annual wage of the construction sector in 2008 was $34,000. Calculated on this basis, the "wage multiplier," the ratio between the wage and the cost per job, is 0.61.[5]

When I compare my results with highway investment, the difference is notable. For example, Garin (2019) shows a cost per job year of $150,000. There are two possible reasons why the employment effects of levee investment are larger. First, the transaction amounts for levee projects are more likely to be small. In particular, while the mean transaction amount in highway projects is $2.1 million, that of the transaction of levee projects is $1.2 million in my sample. The bidding process is also different. While USACE, a Federal government agency, performs procurement for levees, states do this for highways. These differences may also have affected the results. Smaller projects may also be more efficient in hiring labor, because these projects are not likely to use large physical capital. Buchheim and Watzinger (2019) use school buildings in Germany to estimate the fiscal multiplier. Although school buildings are not an infrastructure project, this is a good comparison with levees because it is mainly related to construction. They show a cost per job year of $33,000, which is similar to my result. Generally, the transaction scale for building a school is also small, which might also influence the result.

5.4 Implementation Lags

Policymakers and researchers may be concerned that the program could have implementation lags between the date upon which budget plans were approved and the date that a projects started. Even though the projects related to the ARRA are "shovel-ready", it is possible that the public procurement process may take time. Even after a construction company wins a project, it has to survey local geological conditions and borrow areas based on the characteristics of the project. After such procedures, construction companies can start major construction work and hire more workers. Summers (2008) states that the implementation of investment programs may take such a

[5]The additional effects of distortionary taxes should be taken into account when evaluating the figure. Samuelson (1954) shows that the sum of the marginal rates of substitution must be equal to the marginal rate of transformation. He uses the case in which the government is financed entirely by lump-sum taxation. His analysis is extended by Stiglitz and Dasgupta (1971) and Atkinson and Stern (1974) to account for the more realistic situation in which revenue has to be raised by distortionary taxation. These papers show that a crucial factor in the optimal size of government is the marginal welfare cost of raising revenue through distortionary taxes, subsequently labeled the marginal cost of public funds (MCF) by Browning (1976). Ballard and Fullerton (1992), Dahlby (2008) and Kreiner and Verdelin (2012) provide a recent review of this literature.

Also, it is crucial to account for both the benefits to the public good itself (long-run) and the benefit in terms of mitigating the unemployment (short-run). Michaillat and Saez (2018) propose a theory of optimal public expenditure when unemployment is inefficient. When unemployment is inefficiently high, too many workers are idle. They introduce inefficient unemployment into Samuelson's theory.

long time that they are an ill-suited policy tool for a downturn when quick reactions are required. Becker (2009) also expresses concerns with implementation lags. Both emphasize that properly designed infrastructure projects have the virtue of being helpful as short-run stimulus. Summers proposes the benchmark of attaining this goal within a year. The fact that levee investment had immediate effects on employment alleviates common concerns and suggests that levee projects are an effective way to gain employment effects quickly.[6]

5.5 Seasonal Cycles

Another potential concern is that employment in the construction sector may show a seasonal cycle. While seasonal fluctuations are crucial in designing a short-run stimulus package, they are typically ignored by researchers. For example, building highways in the winter is difficult in cold regions. Geremew and Gourio (2018) present some facts about U.S. employment seasonality. They document that construction employment reaches a minimum in February and a peak around August. There is considerable heterogeneity in the amplitude of the seasonal cycle across states. For example, Florida is less seasonal than Minnesota.

Figure 6 parallels the results in Figure 5, using each year's samples aggregated by season. Table 6 aggregates samples by season and uses regression by season. The estimates for winter are relatively large and are statistically different from zero in terms of both total employment and construction employment. Moreover, Table 6 shows that the estimate for winter in the construction sector is statistically different to those for autumn and summer (the difference between estimates in winter and autumn is $1.29 - 0.60 = 0.69$ and the standard error is $\sqrt{(0.21)^2 + (0.15)^2} \approx 0.26$). One possible interpretation is that seasonal factors should be considered in levee construction. Figure 1 plots the geographic variation in investment. Investment is high in Florida, California, Louisiana, and Missouri. These states have a relatively higher average temperature in January. This fact allows construction firms to build levees in winter. Moreover, high water levels delay levee construction. USACE (2006) points out that damaged structures should be updated prior to flood season. Baldwin and Lall (1999) investigate the seasonality of the upper Mississippi River streamflow, showing that the streamflow reaches a minimum around January and a peak around June. Such facts suggest that building levees in the winter would be ideal. Thus, the employment effect may be larger in the winter.

While previous literature does not examine seasonal cycles in highway construction, such cycles would exist even in highway construction. For example, installing concrete and asphalt, major materials for highways, are challenging in the winter because these materials require dry and relatively high temperatures. On the other hand, filling soil, a major material for levees, does not have such

[6] The ARRA requires federal agencies to report actual weekly outlays, though the data is not available at the county level. By August 2010 (one year after the spending plan was approved), total gross outlays in the Mississippi River and Tributary account, a project heavily reliant on levees, were $143 million, whereas the total obligation was $267 million. This fact supports the statement that implementation lags are short.

a seasonal limitation. Therefore, levee construction may be an efficient policy tool to stimulate construction labor demand in the winter.

6 Robustness Checks and Extensions

6.1 Falsification Tests

One potential concern is that counties with longer levees might have experiencing employment growth before the investment. To address this concern, I estimate the effect of levee length on the change in employment (reduced form equation) prior to the period of interest. This also allows me to check whether the investment is the only channel through which the instrument affects the change in employment. If the positive and significant coefficient found on the ARRA investment in the baseline regressions does indeed reflect a causal effect on employment growth, then the coefficient should be zero when the dependent variable is the length of levees before the commencement of the ARRA.

Figure 7 reports the reduced-form coefficients for this test using data from January 2003 to August 2009. I consider six-month changes in both total employment and employment in the construction sector. I then run my reduced-form estimates on each overlapping six-month period. I rank the coefficients based on their magnitude and report empirical cumulative distribution function. For comparison, I also show the reduced-form estimate for the baseline period, August 2009 to February 2010, with a vertical line.

The results show two key patterns. First, the estimates are centered around 0; the empirical median of the estimate is -0.12 for total employment and -0.01 for construction. That is, the evidence suggests that in the years before the investment related to the ARRA, counties did not experience systematically different employment trends. Second, my baseline reduced-form estimate is large relative to the coefficients in the period before the investment. Both pieces of evidence increase my confidence that the estimates reported above capture the effect of the ARRA rather than underlying differences between counties with longer or shorter levees.

Another test is used to check whether the length of levees is correlated with other county-level unobservables. For instance, labor demands might be affected by geological characteristics. Projects for levees might be challenging if geological conditions are not favorable (i.e., productivity would decrease). More skilled workers might be required to deal with these issues. These conditions would be correlated with the characteristics of levees. Unfortunately, these variables related to productivity are unobservable at the county level. To address this issue, I use county-level house price data in 2009 from Zillow to check the correlation between the instrument, levee length, and typical home value. Housing prices can be used as a proxy for geographic productivity because they are related to geological characteristics. Because the correlation between levee length and home value is 0.02, I find little evidence that these variables are related to one another. This result supports my assumption that the instrument affects the outcome only through investment.[7]

6.2 Heterogeneity

The effects of investment on employment may not be constant in all places. In particular, a given amount of per-capita infrastructure investment might constitute a larger shock to local demand in smaller counties. Even if the underlying effects are constant across counties, it may be easier to detect an effect in smaller labor markets if infrastructure projects constituted larger shocks in such locales. Thus, I test for heterogeneity using the 2009 population. To do so, I use the median to divide counties into two subgroups. I then regress each subgroup using the baseline setting for regression.

These regressions yield coefficients of (1) 2.99 (SE = 1.54) for total employment in smaller-population counties, (2) 1.39 (SE = 0.60) for construction employment in smaller-population counties, (3) −55.2 (SE = 66.0) for total employment in larger-population counties, and (4) −7.86 (SE = 9.33) for construction employment in larger-population counties. Although the differences between the two subgroups are not statistically significant, the estimates in smaller counties are positive, reaching statistical significance in the construction sector. A potential explanation for these observations is that construction markets in smaller counties may be small, so increases in aggregate labor demand will tend to increase the employment level. This result suggests that it may be more effective to focus investment on smaller counties.

6.3 High School Completion

A model of human capital predicts that increases in the wages of workers with low education relative to wages of workers with high education will reduce investment in schooling because the returns to additional years of schooling are diminished. Black et al. (2005) study the effect of the Appalachian coal boom on high school enrollments. Because the fiscal stimulus program might affect high school enrollments, I examine the effect of the investment on high school dropout rates.

To determine these effects, I use enrollment data from the October Supplement of the U.S. Bureau of Labor Statistics' Current Population Survey (CPS). The data includes (1) whether the sample is enrolled at a regular school and (2) whether the sample has finished high school. The U.S Department of Education's National Center for Education Statistics defines dropout rates as follows: the percentage of the population in a given age range who have not finished high school or are not enrolled in school at one point in time. Since most enrollment data are not available at the county level, I aggregate data at the state level. I check the change in dropout rates (1) from 2009 to 2010 and (2) from 2009 to 2011 as an outcome of the equation. These regressions yield

[7] One might be concerned that house prices could be correlated with the investment. Because the correlation between investment and local house prices is 0.1, I find little evidence that these variables are related.

coefficients of (1) 7.95 (SE = 4.42) and (2) −2.95 (SE = 2.04). Since these results are very noisy, I find little evidence that levee investment affects high school completion rates.

7 Conclusion

This study estimates the employment effects of a previously unstudied form of government intervention in ARRA: levee investment. Using a novel and unique instrumental variable, the length of levees, IV results indicate that this ARRA spending had a positive impact on employment. My preferred specifications suggest that $100,000 of marginal investment increased employment by 4.2 job-years, 1.8 of which were in the construction sector. Moreover, levee projects had immediate effects on employment and showed a seasonal cycle. It should be emphasized that the stimulus effects estimated here relate to the effects of one particular stimulus program enacted in a unique economic environment.

One question for future research is whether levee investment has an economic effect in the long run. Investing in infrastructure has two main roles: (1) to preserve and create jobs, and (2) to provide long-term economic benefits by improving productivity. In relation to the second point, many studies have focused on transportation infrastructure. In contrast, there is little literature focusing on flood control infrastructure. Shirai (2020) examines the impact of the MR&T project, the largest flood control infrastructure project in the world, by using regression discontinuity design. More research is needed to inform policymakers about the impact of infrastructure investments on the local economy.

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Figures and Tables

Figure 1: County-level Levee Investments via the ARRA ($)

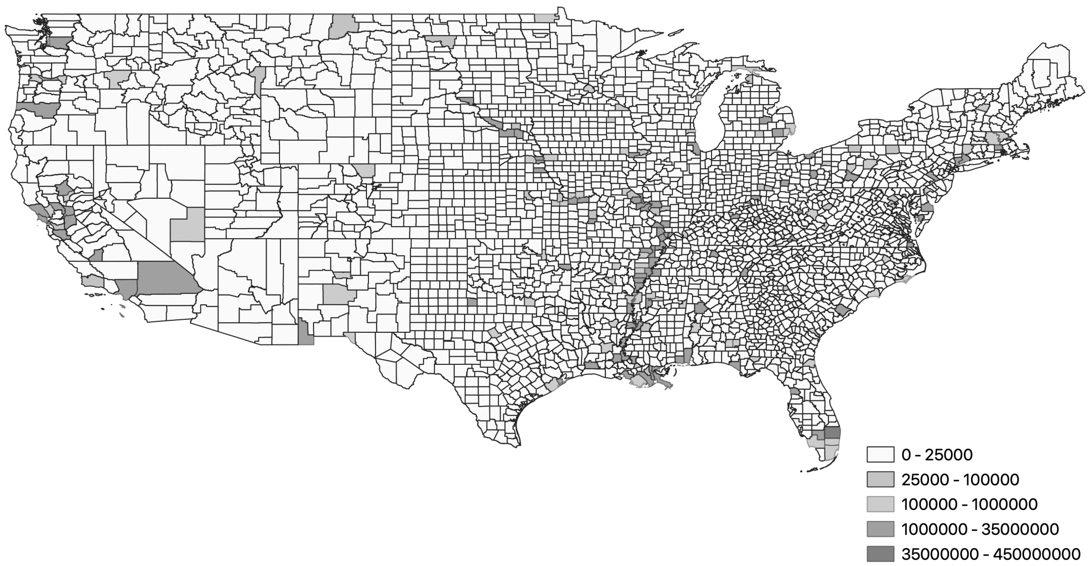


Figure 2: Levees related to USACE

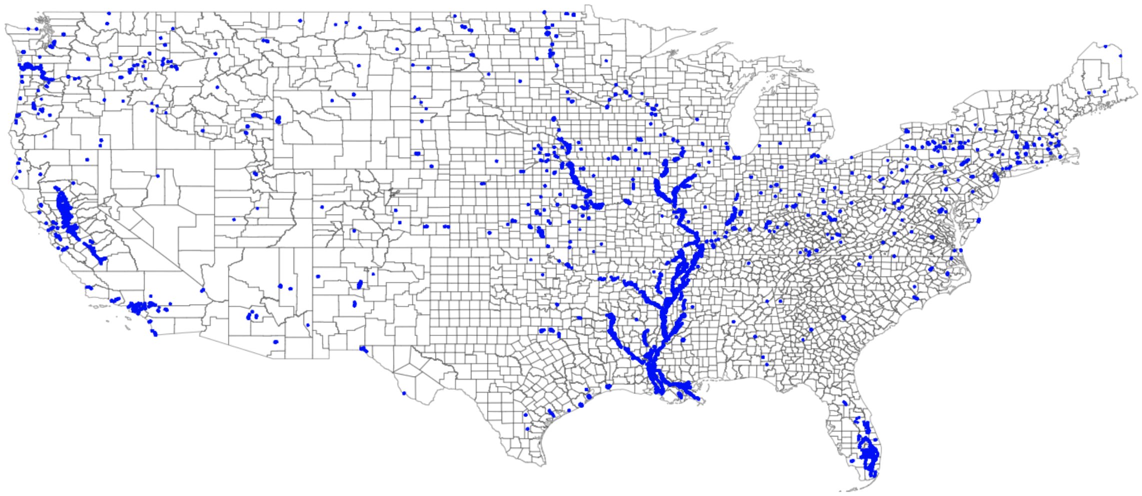
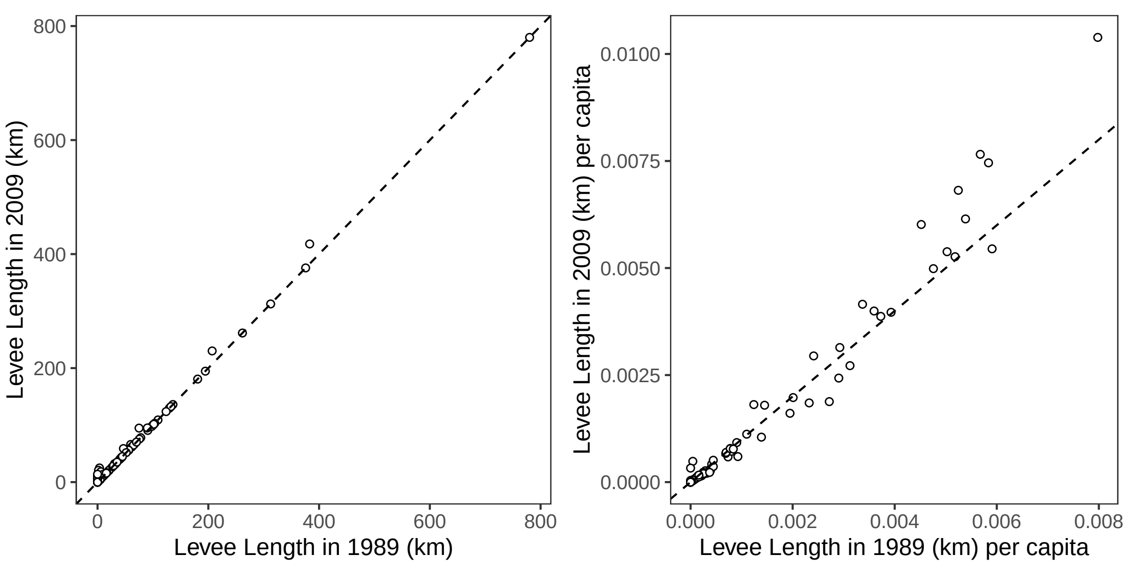
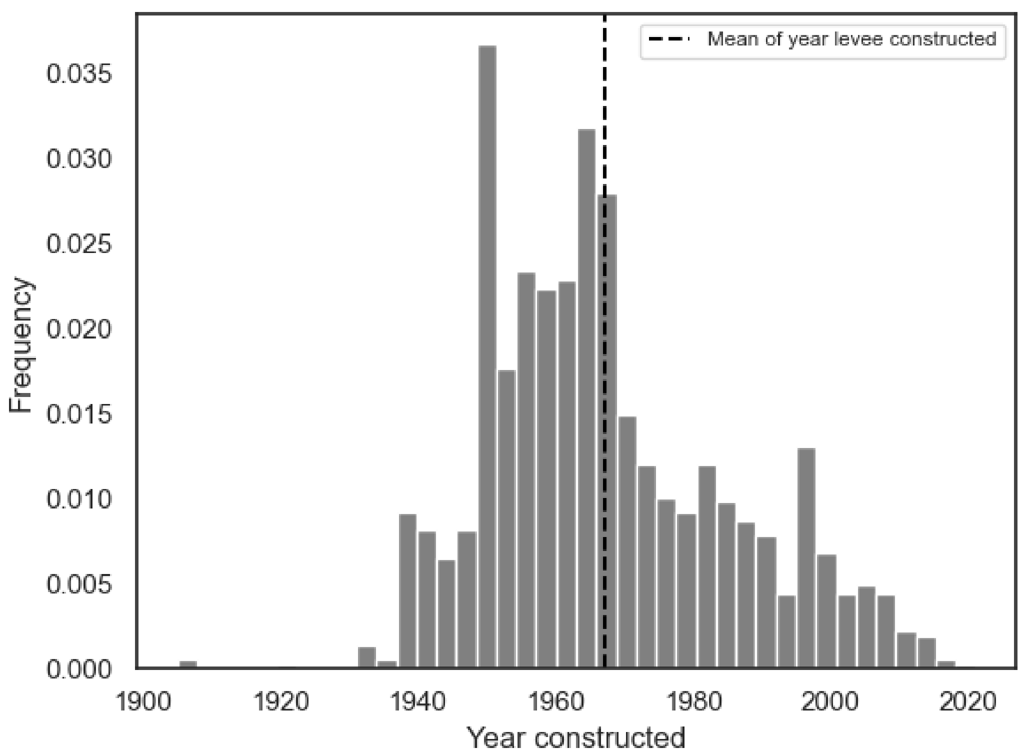


Figure 3: The Autocorrelation of Levee Length between 1989 and 2009



Notes: This figure displays, for each county, the length of levees in 2009 against the length of levees in 1989. The left figure shows the result of the nominal term and the right figure display the result of per capita term. The dashed lines are 45 degree lines.

Figure 4: Constructed year of levees

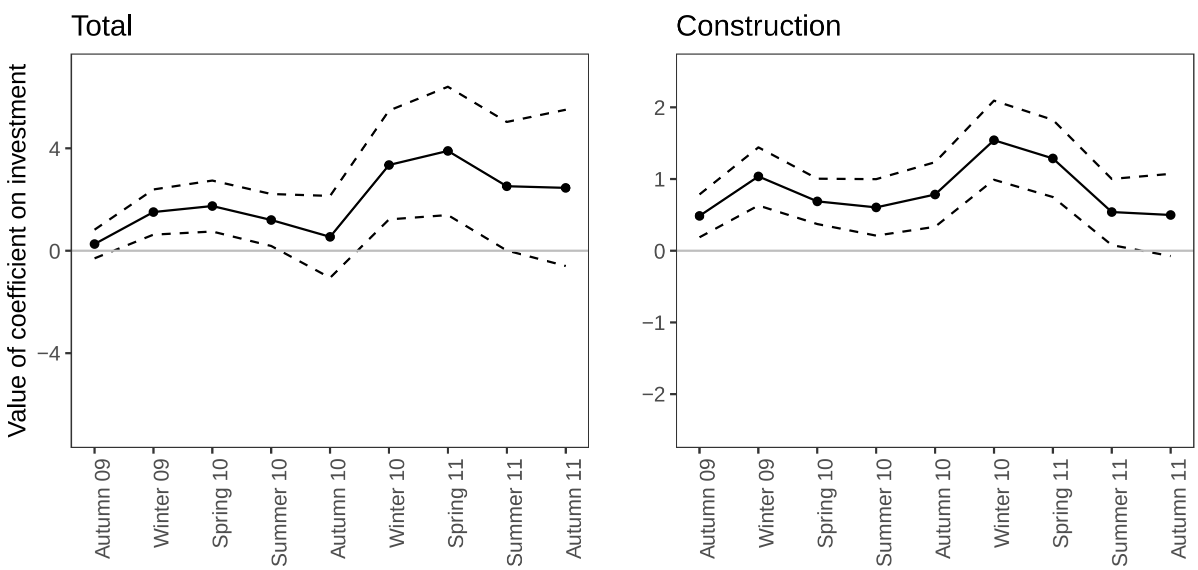


Notes: This figure displays constructed year of levees. The vertical line show the mean of year (1967).

Figure 5: Employment Dynamics

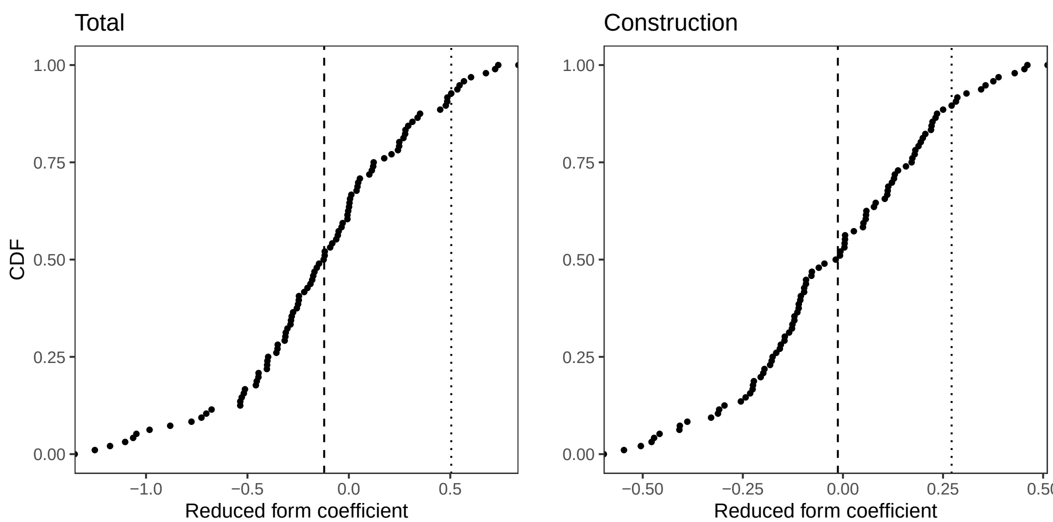
Notes: These charts display the second-stage coefficient for regressions where the outcome variable is the change in employment between August 2009 and the months indicated on the x-axis. The left-hand graph shows the results in total employment of construction-related sectors, and the right-hand graph shows the results in the construction sector. The variable of interest is the investment in levees per working-age population. Regressions include the full set of controls. The 90 percent confidence interval, derived from robust standard errors, is plotted using dashed lines.

Figure 6: Seasonal Cycles of Employment



Notes: These charts display the second-stage coefficient for regressions where the outcome variable is the change in employment, using each year's samples aggregated by season. The left-hand graph shows the results in total employment of construction-related sectors, and the right-hand graph shows the results in the construction sector. The variable of interest is the investment in levees per working-age population. Regressions include the full set of controls. The 90 percent confidence interval, derived from robust standard errors, is plotted in the dashed lines.

Figure 7: Falsification Tests



Notes: Plots results of reduced-form regressions, where the outcome variable is change in employment for each overlapping one year period, starting in January 2000 and ending in August 2009. All regressions include the full set of control variables. Coefficient from August 2009 to February 2010 is indicated with the vertical dotted line. The median of the coefficients is indicated with the vertical dash-dotted line.

Table 1: Summary Statistics

	Mean	SD	Min.	Median	Max.
Outcome variables					
Δ Total Employment, Aug 09 → Feb 10	−2,149	4,753	−40,814	−451	5,614
Δ Construction Employment, Aug 09 → Feb 10	−1,067	2,291	−21,273	−269	8,995
Endogenous variable					
Investment in Levees (M$)	2.275	4.236	0.027	0.880	44.125
Instrumental variable					
Length of Levees (kilometers)	31	81	0	0	780
Control variables					
Total Employment Level, Feb 09	44,631	105,961	0	10,005	1,158,294
Construction Employment Level, Feb 09	7,010	13,187	0	1,834	123,508
Δ Total Employment, Aug 08 → Aug 09	−4,890	11,556	−116,374	−971	5,770
Δ Construction Employment, Aug 08 → Aug 09	−1,519	3,770	−31,593	−248	12,275

Notes: All variables are the nominal term. See text for sources. Note that employment is from the private sector.

Table 2: First Stage Regressions

	(1)	(2)	(3)	(4)	(5)
Panel A. Counties with positive investment					
Levee Length (instrument)	0.29	0.27	0.27	0.27	0.27
	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)
Employment Level (Total)		X	X		
Employment Trend (Total)			X		
Employment Level (Construction)				X	X
Employment Trend (Construction)					X
Partial F-statistic	13.41	10.93	13.50	10.71	10.54
Observations	199	199	199	199	199
Adjusted R^2	0.22	0.25	0.26	0.23	0.23
Panel B. All Counties					
Levee Length (instrument)	0.03	0.03	0.03	0.03	0.03
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Employment Level (Total)		X	X		
Employment Trend (Total)			X		
Employment Level (Construction)				X	X
Employment Trend (Construction)					X
Partial F-statistic	3.79	3.74	3.72	3.77	3.76
Observations	3,107	3,107	3,107	3,107	3,107
Adjusted R^2	0.02	0.02	0.03	0.02	0.02

Notes: All variables are normalized by working-age population. The outcome variable for each regression is the investment in levees per working-age population in a county. Robust standard errors are in parentheses.

Table 3: Employment Effects of Levee Investments (Aug 2009-Feb 2010)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Total employment						
Levee Investment (\$100,000)	1.16	0.80	0.89	2.41	1.97	1.81
	(0.50)	(0.60)	(0.64)	(1.00)	(1.19)	(1.06)
Employment Level (Total)		−0.03	−0.04		−0.02	−0.03
		(0.01)	(0.01)		(0.01)	(0.02)
Employment Trend (Total)			−0.09			−0.10
			(0.19)			(0.18)
First-stage F-statistics				13.41	10.93	13.50
Observations	199	199	199	199	199	199
Panel B. Construction employment						
Levee Investment (\$100,000)	0.50	0.29	0.44	1.29	0.80	0.96
	(0.20)	(0.22)	(0.23)	(0.32)	(0.35)	(0.38)
Employment Level (Construction)		−0.08	−0.13		−0.07	−0.12
		(0.03)	(0.04)		(0.03)	(0.04)
Employment Trend (Construction)			−0.37			−0.37
			(0.22)			(0.22)
First-stage F-statistics				13.41	10.71	10.54
Observations	199	199	199	199	199	199

Notes: The outcome variable for each regression is the changes in employment per working-age population in a county, from August 2009 to February 2010. Panel A uses total employment in construction-related sectors and Panel B uses employment in the construction sector. The main variable of interest is the investment in levees per working-age population. Columns 4-6 instrument the length of levees. Robust standard errors are in parentheses.

Table 4: Employment Effects of Levee Investments (Aug 2009-Feb 2010)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Total employment						
Levee Investment ($100,000)	0.88	0.57	0.91	3.66	0.29	2.09
	(0.48)	(0.54)	(0.49)	(3.75)	(3.62)	(3.34)
Employment Level (Total)		−0.05	−0.07		−0.05	−0.07
		(0.01)	(0.01)		(0.01)	(0.01)
Employment Trend (Total)			−0.21			−0.21
			(0.07)			(0.07)
First-stage F-statistics				3.79	3.74	3.72
Observations	3107	3107	3107	3107	3107	3107
Panel B. Construction employment						
Levee Investment ($100,000)	0.47	0.17	0.47	2.91	−1.92	−0.27
	(0.18)	(0.21)	(0.19)	(2.56)	(2.77)	(2.65)
Employment Level (Construction)		−0.29	−0.32		−0.29	−0.32
		(0.10)	(0.08)		(0.10)	(0.08)
Employment Trend (Construction)			−0.45			−0.45
			(0.13)			(0.13)
First-stage F-statistics				3.79	3.77	3.76
Observations	3094	3094	3094	3094	3094	3094

Notes: The outcome variable for each regression is the change in employment per working-age population in a county, from August 2009 to February 2010. Panel A uses total employment in construction-related sectors and Panel B uses employment in the construction sector. The main variable of interest is the investment in levees per working-age population. Columns 4-6 instrument the length of levees. Robust standard errors are in parentheses.

Table 5: Employment Effects of Levee Investments by Industry

	Mining	Const.	Manuf.	Wholesale	Fin and Ins	Oth. serv.
	(1)	(2)	(3)	(4)	(5)	(6)
Levee Investment ($100,000)	0.19	0.96	0.07	0.58	0.01	−0.12
	(0.16)	(0.38)	(0.91)	(0.78)	(0.08)	(0.29)
Observations	191	199	199	199	199	199

Notes: The outcome variable for each regression is the change in employment of each indicated sector per working-age population in a county, from August 2009 to February 2010. The main variable of interest is the investment in levees per working-age population. Robust standard errors are in parentheses.

Table 6: Employment Effects of Levee Investments by Season

	Autumn	Winter	Spring	Summer
Panel A. Total employment				
Levee Investment ($100,000)	0.92	2.43	2.82	1.86
	(0.61)	(0.71)	(0.83)	(0.83)
Observations (# of counties)	199	199	199	199
Panel B. Construction employment				
Levee Investment ($100,000)	0.60	1.29	0.99	0.57
	(0.15)	(0.21)	(0.19)	(0.18)
Observations (# of counties)	199	199	199	199

Notes: The outcome variable for each regression is the change in employment per working-age population in a county, using samples aggregated by season. Robust standard errors are in parentheses.