

# Was There a Riverside Miracle? An Hierarchical Framework for Evaluating Programs with Grouped Data<sup>\*</sup>

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This paper uses data from the Greater Avenues for Independence (GAIN) demonstration to discuss the evaluation of programs that are implemented at multiple sites. Two frequently used methods are pooling the data or using fixed effects (an extreme version of which estimates separate models for each site). The former approach, however, ignores site effects. Though the latter incorporates site effects, it lacks a framework for predicting the impact of subsequent implementations of the program (e.g., will a new implementation resemble Riverside or Alameda?). I present an hierarchical model that lies between these two extremes. For the GAIN data, I demonstrate that the model captures much of the site-to-site variation of treatment effects, but has less uncertainty than a model which estimates treatment effects separately for each site. I also show that uncertainty in predicting site effects is important: when the predictive uncertainty is ignored, the treatment impact for the Riverside sites is significant, but when we consider predictive uncertainty, the impact for the Riverside sites is insignificant. Finally, I demonstrate that the model is able to extrapolate site effects with reasonable accuracy, when the site for which the prediction is being made does not differ substantially from the sites already observed. For example, the San Diego treatment effects could have been predicted based on observable site characteristics, but the Riverside effects are consistently underpredicted.

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## 1. Introduction

This paper discusses the problem of evaluating and predicting the treatment impact of a program that is implemented at multiple sites; at a methodological level, the paper illustrates the use of hierarchical models for data that has a group (e.g., site) structure. Many programs operate, or are evaluated, at multiple sites, e.g., the National Supported Work Demonstration, Job Training Partnership Act Demonstration, and Greater Avenues for Independence (GAIN). This paper presents a framework for dealing with multi-site programs, and (using data from GAIN) argues that it is essential to consider the site structure of data when evaluating a program.

When data has a site structure, there is a distinction between evaluating a program and predicting the outcome in subsequent implementations. Evaluation is an historical question. One wants to determine what the impact of a program was in a particular site at a particular point in time. Prediction instead relates to future implementations of a program, either at one or more of the sites where the evaluation was conducted or possibly at a new site. Both kinds of questions are potentially challenging with multi-site programs.

The challenge with evaluation is how and to what extent data should be pooled across sites. Differences across sites can emerge for two reasons. There can be differences in the composition of participants, which is addressed relatively easily if a sufficient number of the participants' characteristics are observed. But there can also be site-specific variation in the treatment, differences ranging from the services offered to administrative philosophy. To the extent that site-specific effects are absent and that we can condition on individual characteristics, the benefit of pooling the data is increased

precision in the estimates. This can be particularly important if there are very few observations at some sites. If site effects are present, the data can still be pooled if we allow for fixed effects. However, this leads to difficulties in predicting the impact of the program.

Fixed effects or, more generally, estimating separate models for each site limit us to thinking of subsequent implementations of the program as being identical to one of the original sites, because there is no framework to account for predictive uncertainty regarding the value of the fixed effect or site-specific model. This is true both when predicting the impact at one of the sites in the evaluation (in which case we want to re-draw for the site effect) and when predicting the impact at a new site.

The solution that this paper proposes is hierarchical modeling (see Chamberlain and Imbens [1996], Geweke and Keane [1996], and Rossi, McCulloch, and Allenby [1995] for other applications of these methods). Hierarchical modeling is a middle-ground between fixed effects modeling and pooling the data without fixed effects. Hierarchical modeling is somewhat familiar in the literature through the related concept of meta-modeling (see Cooper and Hedges [1994]). Meta-modeling involves linking the outcomes of separate studies on the same topic through an over-arching model. It can also be used to model site effects; for example, Card and Krueger (1992) estimate cohort and state-of-birth specific returns to schooling and then use a meta-model to relate these to measures of school quality. The method adopted in this paper is a Bayesian version of meta-modeling.

There are three layers to the model: the first involves separate models for each site; the second links the coefficients of the site models through a regression-type meta-

model; and the third consists of prior distributions for the unknown parameters. Thus, an hierarchical model combines features of the fixed-effect and pooled models, but also allows for intermediate models. Compared to standard fixed (or random) effects model, it allows for site-specific estimation of all coefficients, not just the constants. Further, participants across sites are not assumed to be exchangeable conditional on individual characteristics, but rather to be exchangeable within sites conditional on individual characteristics. Finally, we use a prior distribution to model the extent to which we believe that site-effects are drawn from a common distribution; namely, the extent to which coefficients should be “smoothed” across sites, or observations from one site should influence our estimates in other sites.

This approach is applied to data from the GAIN Demonstration, a labor training program implemented in six California counties at 24 sites (see Riccio, *et al.*, [1996]). For the GAIN data, the primary benefit of applying hierarchical models is in terms of prediction rather than evaluation. Each site has a sufficient number of observations so that the gain in precision from pooling data from other sites is limited. However, the predictive questions are of central importance. Much attention in the GAIN program focused on the Riverside county implementation, which was viewed as being highly successful and distinct from other counties (see, for example, Nelson [1997]). Our interest is in discovering the extent to which an hierarchical model succeeds in capturing these site effects which have been viewed as being primarily qualitative in nature. We focus on three issues. First, does data from other sites help in evaluating the program at a given site? Second, if we imagine re-implementing a GAIN-type program, would we be able to predict the site effects based on the observable characteristics of

each site, and how important is predictive uncertainty? Third, how well can the model extrapolate to sites that have not been observed?

Previous papers on multi-site evaluation issues include: Heckman and Smith (1996), Hotz, Imbens, and Mortimer (1998), and Hotz, Imbens, and Klerman (2000). Heckman and Smith analyze the sensitivity of experimental estimates to the choice of sites used in the analysis and to different methods of weighting the pooled data. Their paper establishes that there is significant cross-site variation in the data from the JTPA evaluation. Hotz, Imbens, and Mortimer analyze the importance of site effects in the Work Incentives demonstration using the key insight that, even if there is heterogeneity in the treatment available at each site, control groups excluded from the treatment still should be comparable. They find that control group earnings are comparable across sites, when controlling both for individual characteristics and for site-level characteristics; however, post-treatment earnings for the treated group earnings are not comparable, suggesting the existence of heterogeneity in the treatment. Taken together, both papers motivate the use of an hierarchical model, which allows explicitly for site effects in treatment and control earnings and directly incorporates site-level characteristics.

Hotz, Imbens, and Klerman is complementary to this paper. It examines the GAIN data using the same framework as Hotz, Imbens, and Mortimer, and the findings are also similar. The authors are able to adjust for differences in control group earnings using individual and site-level characteristics. However, differences remain in post-treatment earnings. The paper thus presents a series of differences-in-differences estimates which, inter alia, suggest that the treatment available at Riverside did have a

positive effect relative to the treatment offered at other sites. This finding will be discussed in Section 5.

This paper is organized as follows. Section 2 describes the GAIN program. Section 3 discusses key features of the GAIN data. Section 4 outlines the hierarchical model. Section 5 presents the results, and Section 6 concludes.

## **2. The GAIN Program**

The GAIN program began operating in California in 1986, with the aim of “increasing employment and fostering self-sufficiency” among AFDC recipients (see Riccio, *et al.*, [1994]). In 1988, six counties -- Alameda, Butte, Los Angeles, Riverside, San Diego, and Tulare -- were chosen for an experimental evaluation of the benefits of GAIN. A subset of AFDC recipients (single parents with children aged six or older and unemployed heads of two-parent households) were required to participate in the GAIN experiment (see Table 1).<sup>1</sup>

Potential participants from the mandatory group were referred to a GAIN orientation session when they visited an Income Maintenance office (either to sign up for welfare or to qualify for continued benefits).<sup>2</sup> As a result, the chronology of the data and subsequent results are in experimental time, rather than calendar time. No sanctions were used if individuals failed to attend the orientation sessions. However, once individuals started in the GAIN program, sanctions were used to ensure their ongoing participation. At the time of enrollment into the program, a variety of background characteristics were recorded for both treatment and control units including: demographic characteristics;

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<sup>1</sup> This discussion draws on Dehejia (1999).

results of a reading and mathematics proficiency test; and data on ten quarters of pre-treatment earnings, AFDC, and food stamp receipts.<sup>3</sup>

Of those who attended the orientation session, a fraction was randomly assigned to the GAIN program,<sup>4</sup> and the others were prohibited from participating in GAIN.<sup>5</sup> Each of the counties randomized a different proportion of its participants into treatment, ranging from a 50-50 split in Alameda to an 85-15 split in San Diego (see Table 1). Because assignment to treatment was random, the distribution of pre-treatment covariates is balanced across the treatment and control groups. In terms of the chronology of data gathering, “experimental” time (which I also refer to as “post-experimental” or “post-treatment” time) begins when individuals attend the GAIN orientation session. The early stages of experimental time thus coincide with the education and training of GAIN participants.<sup>6</sup>

In the GAIN experiment, the treatment is participating in the GAIN program; the control is receiving standard AFDC benefits. The GAIN program works as follows: based on test results and an interview with a case manager, participants were assigned to one of two activities. Those deemed not to be in need of basic education were referred to a job search activity (which lasts about three weeks); those who did not find work were

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<sup>2</sup> In some counties AFDC recipients were allowed to volunteer into the GAIN program, but these units are not included in the public use sample.

<sup>3</sup> Data on AFDC and Food Stamp receipts were taken from each county’s welfare records. Data on earnings were taken from the California State Unemployment Insurance Earnings and Benefits Records. Other background characteristics were taken from California’s client information (“GAIN-26”) form. See Riccio, *et al.*, (1994).

<sup>4</sup> The randomization was (as far as we know) independent of pre-treatment covariates. This is confirmed by the data. A different fraction was randomized into treatment in each county. See Table 1.

<sup>5</sup> Of course, these individuals could participate in non-GAIN employment-creating activities.

<sup>6</sup> More precisely, individuals were registered in the first quarter of experimental time. This means that in some cases the first quarter of experimental time in fact includes information one or two months prior to the commencement of the experiment. So for example, for an individual who attended an orientation session in February 1989, the first quarter of experimental time is from January to March 1989. Of course,

placed in job training (which included vocational or on-the-job training and paid or unpaid work experience, lasting about three to four months). Those deemed to be in need of basic education could choose to enter job search immediately, but if they failed to find a job they were required to register for preparation toward the General Educational Development certificate, Adult Basic Education, or English as a Second Language programs (lasting three to four months).<sup>7</sup> Participants were exempted from the requirement to participate in GAIN activities if they found work on their own.<sup>8</sup>

The counties in the GAIN experiment varied along two important dimensions. First, the composition of program participants varied, because counties chose to focus on particular subsets of their welfare populations and the populations differed. For example, Alameda and Los Angeles counties confined themselves to the subset of long-term welfare recipients (individuals having already received welfare for two years or more). The second difference is that the sub-treatment offered within each county varied due to differences in administrative philosophy. The approach followed by Riverside, which has received much attention, was to focus on job, rather than skills, acquisition. Both are part of the program, but Riverside's emphasis was the former. Instead counties like Alameda focused more on skill acquisition. The model will allow for differences in composition by

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some part of the first and second quarters could be spent participating in treatment activities. Pre-treatment data would cover the ten quarters from July 1986 to December 1988.

<sup>7</sup> The public use data do not contain information on each individual's participation in the various components of the program. At the same time, individuals in the control group can participate in non-GAIN activities. Thus, the treatment effect measures the increase in earnings, employment, etc., from the availability of and encouragement (or requirement) to use GAIN-related activities compared to pre-existing employment services.

<sup>8</sup> Note that only about eight-five percent of the treated units actively participated in any GAIN activities (though by virtue of being in the GAIN sample they did attend an orientation meeting); the balance satisfied the requirements of the GAIN program on their own (in most cases finding employment within the first two or three quarters of experimental time). Thus, as observed earlier, this is important in interpreting the treatment effect as a comparison between earnings, employment, etc., when individuals are required to find a job or to participate in GAIN-related activities and when they are not obliged to find jobs and only pre-existing employment-related services are available.

conditioning on pre-treatment covariates and differences in the treatment by allowing for site effects.

### **3. The GAIN Data**

Table 1 presents the six counties that participated in the GAIN experiment, broken down in terms of their 24 administrative sites. The counties vary from one-site counties such as Alameda to multi-site counties such as Los Angeles and San Diego. This paper will analyze the results at the site level because with six counties there is minimal scope for modeling site effects. Table 2 presents the background characteristics of each site in greater detail. We note that the average number of children varies from over four in some sites (site 21) to slightly over two in others (site 6). The proportion of Hispanics in the sample varies from a low of 6 percent (site 1) to over 50 percent in other sites (sites 14 and 24).

Table 2 shows that there is significant variation in the treatment impact across sites. The second-last row presents the average quarterly post-treatment earnings for the treatment and control groups. The treatment impact ranges from a high of \$212 for Site 5 (in Riverside county) to a low of -\$132 for Site 17 (in Tulare). In the last row the treatment effect is estimated conditioning on pre-treatment covariates through an OLS regression. The estimates are similar, ranging from -\$90 to \$292. The sites consistently showing the highest and most significant impacts are those from Riverside county (sites 2 to 5). Their treatment impacts range from \$149 to \$292, and are significantly different from zero. The worst performing county is Tulare, for which some of the impacts are negative and all are statistically insignificant.

#### 4. The Econometric Model

An important feature of the data which influences the modeling strategy is the large proportion of zeros in the outcome, earnings. With as many as 75 percent of the outcomes being zero, the model must explicitly account for the mass point in the earnings distribution. The most parsimonious model for dealing with a mass point at zero is the Tobit model.

##### 4.1 The Hierarchical Model

The hierarchical model (see Gelman, Carlin, Stern, and Rubin [1996]) is a generalization of the regression model that allows each site to have its own value for the coefficients:

$$Y_{ijt}^* \left| \left\{ x_{ijt} \right\}_{i,t,j} b_j, s^2 \sim N(b_j' x_{ijt}, s^2), \quad (1)$$

where  $Y_{ijt}$  is observed income and  $Y_{ijt}^*$  is a latent variable such that  $Y_{ijt}=0$  if  $Y_{ijt}^* < 0$  and  $Y_{ijt}=Y_{ijt}^*$  if  $Y_{ijt}^* > 0$  (the Tobit model), with  $i=1, \dots, I$  (individuals),  $t=1, \dots, T$  (time periods), and  $j=1, \dots, J$  (sites), and where  $x_{ijt}=[c_{ijt} T_i c_{it}]$ ,  $T_i$  is a treatment indicator (=1 if treated, =0 otherwise), and  $c_{it}$  is a vector of exogenous pre-treatment variables.

Let  $b_j' = (b_{j1} \dots b_{jM})$ , where  $m=1, \dots, M$  indexes the regressors. The model assumes a constant variance across sites. The key feature of the model is that the  $b$ 's are linked through a further model:

$$b_{jm} \left| \left\{ z_j \right\}_{j=1}^J, g_m, \Sigma \sim N(g_m' z_j, \Sigma), \quad (2)$$

where  $z_j$  are a set of site characteristics used to model the site coefficients. The model for  $b$  serves as a prior distribution with respect to the base model for earnings.

The model is completed by defining priors for the parameters:

$$1/s^2 \sim W_1(r, Q^{-1}),$$

$$\Sigma^{-1} \sim W(r, K),$$

and

$$\text{vec}(g) \sim N(d, \Sigma \otimes D).$$

The prior on  $\Sigma^{-1}$  determines the degree of smoothing the model performs. The estimate of the  $b$ 's for each site are a precision-weighted average of the OLS estimates within each site and the  $b$ 's predicted by the model in (3). The weight, in turn, is influenced by the prior for  $\Sigma^{-1}$ . The Wishart prior can be interpreted as  $r$  previous observations with variance  $K^{-1}$ . When  $K^{-1}$  reflects high variance, this will pull up the estimate of  $\Sigma$  (hence reduce the estimated prior precision,  $\Sigma^{-1}$ ), and lead to a lower weight being placed on the common prior for  $b$ 's and a higher weight on the  $b$  estimated within each site.

Estimation is undertaken using a Gibbs sampler (outlined in the Appendix).<sup>9</sup>

#### 4.2 The Predictive Distribution

Since the object of interest for the policy question is earnings, and only indirectly the parameters, we generate the predictive distribution, the distribution in the space of outcomes that captures all of the uncertainty from the model, both intrinsic uncertainty and parameter uncertainty. This distribution is simulated by repeatedly drawing for

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<sup>9</sup> Note that the hierarchical model could also be estimated using maximum likelihood methods. The limitation in doing this is that the number of sites is very small. This not only renders standard asymptotic approximations of the distributions of parameters unreliable, but it also makes it hard to estimate parameters such as  $\Sigma^{-1}$  exclusively from the data (i.e., without the use of a prior).

parameter values from their posterior distribution and then drawing from the outcome distribution conditional on observed data and parameters.

## 5. The Results

The model outlined in the previous section is implemented on the GAIN data, using age, education, number and age of children, previous participation in a training program, reading and writing test scores, ethnicity, and pre-treatment earnings as pre-treatment individual characteristics. These are interacted with the treatment indicator, so that the model allows for the site effect for treatment in control earnings to be different. The mean characteristics of participants (including the mean number of children, mean reading score, mean level of education, mean age, and mean pre-treatment earnings) are used as the site characteristics. The Gibbs sampler outlined in the appendix produce estimates of the posterior distribution of the parameters. These are then used to produce a predictive distribution of earnings (under treatment and control) for each individual. The predictive distributions are then averaged over the individuals at a site to produce an estimate of the site impact.

### 5.1 Site effects and evaluation

This subsection examines to what extent observations from other sites help in evaluating the program at a particular site. In general, this is an empirical question: the answer depends on the dataset under consideration. From the previous section, recall that the degree of smoothing performed by the hierarchical model depends on  $\Sigma^{-1}$ , and the estimate of this parameter in turn is influenced by  $K^{-1}$ , which is a prior. If  $K^{-1}$  is small,

then this pulls down the estimate of  $\Sigma^{-1}$ , which in turn means that a lower weight is put on the common prior, and a higher weight on the within-site estimates. By varying  $K^{-1}$ , the results of the hierarchical model range from fully pooled to site-by-site estimates. Because the number of site observations typically is small (24 for the GAIN data), the prior will have a substantial influence on the final estimate of  $\Sigma^{-1}$ . The empirical question then becomes to what extent does the choice of smoothing prior influence the estimate of earnings and the treatment effect within each site.

Table 3 presents estimates of the Tobit model under a range of assumptions. In the first row, the earnings are estimated using a non-hierarchical Tobit, estimated from the pooled data; these estimates ignore site effects. In row (2), Tobits are estimated individually for each site. The next two rows present estimates from the hierarchical Tobit model. In row (3) the prior is chosen so that minimal smoothing is performed, and in row (4) the prior is chosen to induce a greater degree of smoothing. Of the four models, the site-by-site Tobit and the minimally smoothed hierarchical models should be nearly identical: when the prior is selected for minimal smoothing, it essentially induces site-by-site Tobits. This is confirmed by comparing rows (2) and (3).

In comparing the pooled estimates with those from the site-by-site (or minimally smoothed) models, we observe that the results differ substantially through not dramatically. For treatment (control) earnings, the mean difference is \$25 (−\$6), with a mean absolute deviation of \$69 (\$56). This reflects the obvious fact that the site-by-site estimates bounce around more than the pooled estimates. The estimated treatment effects implied by these models are depicted in Figure 1, panels (a) and (b) (along with the 2.5 and 97.5 percentiles of the predictive distributions of the average treatment effect). The

site-by-site estimates represent unbiased estimates of the site-treatment effects. The advantage of pooling is reflected in the lower standard errors of the estimates in panel (a).

Panel (c) depicts the estimated treatment effect from the smoothed hierarchical model. As one would expect, the estimates lie between those of the other two models. They are less dispersed than the site-by-site estimates, and have somewhat smaller uncertainty bounds. The mean absolute deviation for the treatment effect with the pooled model is \$53, and the 2.5-97.5 percentile uncertainty bounds are narrower by about \$17 on average.

Overall, all three panels depict a broadly similar profile of treatment effects, but the differences in the uncertainty bounds qualitatively affect the results. In panel (b) 10 of the 24 treatment effects are insignificant (in the sense that 2.5-97.5 percentile bounds include zero), but only one treatment effect with the pooled estimates is insignificant and only three for the smoothed estimates. It is important to note that there is neither an a priori nor an empirical basis to choose between these estimates. If one were forced to pick a single estimate, the choice would depend on the smoothing prior that could be comfortably adopted. Of course, looking at the range of estimates is also quite informative.

A concrete illustration of the role that site effects can play is afforded in Table 3, row (5). The counterfactual exercise presented is to assign the individuals from a given site (site 19, Alameda) into sites. The same site-effects are used as in Table 3, row (3). The thought experiment is to determine earnings for Alameda participants if, for example, they had entered the program in the environment of Riverside. As we vary the sites we see that there is variation in both estimated earnings and the treatment impact for

these individuals. The level of treatment (control) earnings varies from \$267 (\$226) in site 24 (site 19) to \$545 (\$749) in site 3 (site 13). The treatment effect varies from  $-\$262$  in site 13 to  $\$239$  in site 3. Note that the Alameda participants are predicted to have a higher treatment effect if they had participated in the Riverside treatment. Hotz, Imbens, and Klerman have a similar finding, but they note that this effect attenuates beyond the 13 quarters of earnings observed in the current dataset.

### *5.2 Are there county effects?*

The GAIN data has both a site structure and a county structure. The model discussed in Section 5.1 ignores the county structure of the data. The difficulty in dealing with county-level effects is that we observe only six counties in the data. With six observations, it would be difficult to estimate even a single-parameter model. Table 4, however, suggests that county effects are not a source of concern in the GAIN data, once we have modeled site effects. It summarizes the explanatory power of county-level dummies on the site-level estimated coefficients of the model (using adjusted  $R^2$ ). The 2.5 and 97.5 percentile intervals for adjusted  $R^2$  are very broad, and always include zero.

### *5.3 In-sample predictive uncertainty*

The analysis thus far has taken the profile of site-effects as given. In this section we examine the GAIN program from a predictive perspective. If we were to re-implement the GAIN program, allowing for new site effects in each site (hence predictive uncertainty), then would the treatment effects be significant? In Table 3, row (5), the parameters for each site are re-estimated based on each site's characteristics.

The relevant comparison is to the estimates in Table 3, row (3), which ignore uncertainty in the site effects. The immediate observation is that the results are quite similar, typically within \$50. At one level this may seem trivial: since the data for a given site are included in the estimation, it may not seem surprising that we are able to predict the treatment with reasonable accuracy. However, the result is not trivial, because for each site we draw new site parameters based on the hierarchical model and base predictions on these parameters. So, for example, when we predict the outcome for site 6, the characteristics of its participants imply a set of site characteristics, which in turn produce a set of site parameters that lead to the average earnings we estimate.

However, the range of uncertainty increases substantially (see Figures 6 and 7). In Figure 2, the 2.5-97.5 percentile intervals of the posterior distributions overlap to a large extent for 11 of 24 sites, and in this sense the treatment effects are not significant. In Figure 3, the 2.5-97.5 percentile intervals for average earnings overlap for all of the 24 of sites. In particular, for sites 2, 3, 4 and 5 (the Riverside sites), as shown in Figure 2, the posterior 95 percent probability intervals do not overlap, but they do in Figure 3. Overall, the comparison of the two sets of estimates suggests that when the site-specific parameters are re-estimated for each site, we succeed in replicating a profile of outcomes similar to those that are obtained for each site in isolation. However, uncertainty increases, in some cases significantly.

#### *5.4 Out-of-sample predictive uncertainty*

An important question regarding site effects is whether we would be able to predict the outcomes at a site if we had not observed that site in our data. In other words, are site

effects so important that it is difficult or impossible to predict the treatment effect at a given site using data from other sites? To explore this issue, the estimates in Table 3, row (6), drop each site successively and use the remaining sites to predict its outcome. Point estimates of treatment effects (means of the predictive distributions) are plotted in panels (a) and (b) of Figure 4. (The 2.5-97.5 percentile bounds are not plotted in panels (b) and (c) because they cover almost the entire range of earnings.) The results for the two models are broadly similar. The estimated treatment effects are within \$80 on average. Of course, some sites, for example Site 13, are off by much more. The Riverside sites are underpredicted by \$80 to \$150.

One important limitation of this result is that, even though we are excluding the site for which we are predicting the outcome, we include other sites from the same county. Is it possible to estimate the profile of treatment effects across sites if we exclude all of the observations from a county when estimating the model for a particular site? The answer is presented in Table 3, row (7), and Figure 4, panel (c). For most sites the predictions are less accurate than when other sites within the county are included. The estimates of the treatment effect differ from the full-data estimates by an average of \$150. The Riverside sites once again are underpredicted, in this case by \$114 to \$170. Site 13 is underpredicted by \$307. The Los Angeles sites, which are underpredicted by an average of \$30 in panel (b), are overpredicted by an average of \$157 in panel (c).

The difficulty in accurately predicting the treatment effects for these sites illustrates the limitation of any model in extrapolating or predicting the treatment impact at a site that is significantly different from the sites observed in the sample. Site 13 is notably different from other sites because it has no Blacks or Hispanics; it also has the

lowest average level of education among participants. Likewise, the Los Angeles sites differ from other sites in terms of the number of children, which is higher than at other sites, and pre-treatment earnings, which are lower than at other sites. An estimator or a functional form that is more flexible in terms of pre-treatment covariates should yield a more reliable prediction of the treatment impact.<sup>10</sup> In contrast, the Riverside sites do not stand out in terms of their pre-treatment site characteristics. The differences from other sites presumably are along qualitative dimensions of the treatment applied. The inability to predict the Riverside treatment effects supports the view that Riverside differed from other counties in the approach it took to administering the treatment. Predictions based on other sites consistently under-estimate the treatment impacts in Riverside.

## 6. Conclusion

This paper has discussed the use of hierarchical methods to gain insight into the GAIN data and also, more generally, to illustrate the application of these methods to datasets which have a group or site structure.

When a dataset has a group or site structure, and when there is meaningful heterogeneity across sites, hierarchical methods are a potentially useful tool: they allow for a flexible modeling of site effects, for clearly distinguishing between questions of evaluation and prediction, and for controlling the degree of smoothing (or pooling) that the model performs with an explicitly specified parameter. The usefulness of hierarchical methods is not confined to program evaluation. Any site or grouping structure (e.g., patients within a hospital, plants within a firm or under a particular manager, students

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<sup>10</sup> See for example Dehejia and Wahba (1998,1999), Heckman, Ichimura, and Todd (1997, 1998), and Rosenbaum and Rubin (1983, 1985) who use propensity score methods for this purpose.

within a school) offers a potential application of these methods. Depending on the application, hierarchical methods need not be estimated using Bayesian techniques. In the present application, because the number of sites was very small, the use of the smoothing prior was essential. In an application where the number of sites is larger, it would be possible to allow the data to determine the degree of smoothing the model performs and to use standard maximum likelihood methods.

Regarding the GAIN data, this paper has addressed three questions: (1) To what extent are site effects important in evaluating a program? (2) Does predictive uncertainty regarding site effects influence the interpretation of the treatment effect? and (3) Would we be able to predict the outcome for a site, if its data were not observed. The answer to the first question is that, even after accounting for differences in the composition of program participants across sites, site-specific effects are important. Site-by-site estimates are more variable and involve more uncertainty than pooled estimates. The smoothed hierarchical estimate offers a compromise between these two.

The second and third questions are different because they deal with predictive uncertainty for subsequent implementations of the program. When making in-sample predictions, the model can predict the profile of site effects with reasonable accuracy. This amounts to saying that even the simple set of site-level characteristics used in the hierarchical model are sufficient to identify the distinct profile of site impacts in the GAIN data. However, we also find that the predictive uncertainty is important in the sense that the treatment effect for many sites ceases to be significant when predictive uncertainty is incorporated into the estimate. Finally, when making out-of-sample predictions, the quality of the prediction was found to depend upon observing a sufficient

number of sites similar to the one for which predictions are being made. For example, when dropping even some of the Riverside sites, the quality of the predictions for all Riverside sites declines. This is not true for the Los Angeles sites when they are dropped singly, but becomes true when all of the observations from Los Angeles are excluded.

Was there a Riverside miracle? The received wisdom regarding the GAIN program is that qualitative site-specific factors played an important role. The results presented here suggest that a simple set of site characteristics are sufficient to distinguish the various site-level effects. To this extent, there was nothing miraculous about Riverside. However, the results also suggest that substantial extrapolation from the sites that are observed to new sites potentially can be misleading. For example, the Riverside treatment effects are consistently under-predicted when excluding data from all Riverside sites. Thus, more precisely, there is nothing miraculous about Riverside if one observes similar sites in the data. However, in the absence of data on similar sites, Riverside is difficult to predict and to that extent is a miracle.

There are many possible extensions to this work. First, the set of site characteristics used were rudimentary, and in principle could be extended to include features of the local labor market or perhaps even characteristics of the program administrators. It would be interesting to discover how much additional precision could be obtained in that way. Second, the true economic significance of the range of predictions from the models can be assessed only if there is an explicit decision problem. Would the added uncertainty in predicting site-level effects be sufficient to alter the policymaker's decision regarding which program to choose? These are questions for on-going research.

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### Appendix: The Gibbs Sampler for the Hierarchical Model

$$(1) \mathbf{b}_j^{(l)} \sim N(\bar{\mathbf{b}}_j, V_b^{(l-1)}), \text{ where } \bar{\mathbf{b}}_j = (\mathbf{X}_j' \mathbf{X}_j \mathbf{s}_{(l-1)}^{-2} + \Sigma_{(l-1)}^{-1})^{-1} (\mathbf{X}_j' \mathbf{X}_j \mathbf{s}_{(l-1)}^{-2} \hat{\mathbf{b}} + \Sigma_{(l-1)}^{-1} \mathbf{b}^p),$$

$$\hat{\mathbf{b}} = (\mathbf{X}_j' \mathbf{X}_j)^{-1} \mathbf{X}_j' \mathbf{y}_j, \mathbf{b}^p = \mathbf{g}_{(l-1)}' \mathbf{z}_j, \text{ and } V_b = [\mathbf{X}_j' \mathbf{X}_j \mathbf{s}_{(l-1)}^{-2} + \Sigma_{(l-1)}^{-1}]^{-1},$$

$$(2) 1/\mathbf{s}_{(l-1)}^2 \sim c_{(n+r)}^2 / (Q^{-1} + s^2), \text{ where } [s_{ij}] = y_{ij} - \mathbf{b}_j^{(l)} x_{ij} \text{ and } s^2 = \mathbf{s}' \mathbf{s},$$

$$(3) \Sigma_{(l)}^{-1} \sim W(J - M + r, (S + K^{-1})^{-1}), \text{ where } S = \sum_{t=1}^J \mathbf{e}_t' \mathbf{e}_t \text{ and } \mathbf{e}_t = \mathbf{b}_t - \mathbf{g}_t \mathbf{z}_t \text{ (the } M \times 1 \text{ vector of residuals for each site observation),}$$

$$(4) \mathbf{g}^{(l)} \sim N(\tilde{\mathbf{g}}, \Sigma_{(l)} \otimes (\mathbf{Z}' \mathbf{Z} + \mathbf{D}^{-1})^{-1}), \text{ where } \mathbf{g} = (\mathbf{g}_1 \cdots \mathbf{g}_M)', \tilde{\mathbf{g}} = \text{vec}(\bar{\mathbf{g}}),$$

$$\bar{\mathbf{g}} = ((\mathbf{Z}' \mathbf{Z}) + \mathbf{D}^{-1})^{-1} (\mathbf{Z}' \mathbf{Z} \hat{\mathbf{g}} + \mathbf{D}^{-1} \mathbf{d}), \text{ and } \hat{\mathbf{g}}_j = (\mathbf{z}_j' \mathbf{z}_j)^{-1} \mathbf{z}_j' \mathbf{b}_j.$$

This procedure produces a sequence of draws from the parameters, the first 500 of which we discard, leaving us with draws from the posterior distribution of the parameters.

**Table 1: The Sample**

|                 | Alameda | Butte | Los Angeles | Riverside | San Diego | Tulare |
|-----------------|---------|-------|-------------|-----------|-----------|--------|
| <b>GAIN:</b>    |         |       |             |           |           |        |
| Treated Group   | 685     | 1717  | 3730        | 5808      | 8711      | 2693   |
| Control Group   | 682     | 458   | 2124        | 1706      | 1810      | 1146   |
| Total           | 1367    | 2175  | 5854        | 7514      | 10521     | 3839   |
| Number of Sites | 1       | 1     | 5           | 4         | 8         | 5      |

Notes: The GAIN sample sizes are from the public use file of the GAIN data. The AFDC total represents the number of AFDC cases (both single-parent and two-parent households) in the six evaluation counties in December 1990 (see Riccio, *et al.* (1994), Table 1.1).

Table 2: Site Characteristics from the GAIN Experiment

|                                                                      | Butte            |                  | Riverside        |                  |                 | San Diego       |                  |                  |
|----------------------------------------------------------------------|------------------|------------------|------------------|------------------|-----------------|-----------------|------------------|------------------|
| Variable<br>(sample<br>size)                                         | Site 1<br>(2165) | Site 2<br>(3364) | Site 3<br>(2052) | Site 4<br>(1358) | Site 5<br>(706) | Site 6<br>(755) | Site 7<br>(1457) | Site 8<br>(1104) |
| <b>Number of children</b>                                            |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 2.49             | 2.69             | 2.81             | 2.87             | 2.65            | 2.19            | 2.8              | 2.50             |
| Control                                                              | 2.54             | 2.69             | 2.91             | 2.77             | 2.44            | 2.27            | 2.74             | 2.53             |
| (se on diff)                                                         | (0.09)           | (0.08)           | (0.1)            | (0.13)           | (0.14)          | (0.15)          | (0.13)           | (0.13)           |
| <b>Reading test score</b>                                            |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 232              | 231              | 232              | 231              | 231             | 230             | 231              | 231              |
| Control                                                              | 227              | 228              | 227              | 227              | 226             | 229             | 229              | 227              |
| (se on diff)                                                         | (4.56)           | (2.67)           | (4.28)           | (3.55)           | (4.89)          | (1.73)          | (2.02)           | (3.84)           |
| <b>Grade</b>                                                         |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 10.99            | 10.8             | 10.66            | 9.59             | 10.96           | 11.75           | 10.56            | 11.43            |
| Control                                                              | 10.83            | 10.68            | 10.65            | 9.57             | 11.02           | 11.98           | 10.4             | 11.29            |
| (se on diff)                                                         | (0.14)           | (0.1)            | (0.14)           | (0.21)           | (0.17)          | (0.24)          | (0.2)            | (0.18)           |
| <b>Previous training experience</b>                                  |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 0.22             | 0.23             | 0.28             | 0.14             | 0.22            | 0.10            | 0.12             | 0.04             |
| Control                                                              | 0.24             | 0.24             | 0.25             | 0.14             | 0.22            | 0.09            | 0.11             | 0.06             |
| (se on diff)                                                         | (0.02)           | (0.02)           | (0.02)           | (0.02)           | (0.04)          | (0.03)          | (0.02)           | (0.02)           |
| <b>Hispanic</b>                                                      |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 0.06             | 0.24             | 0.18             | 0.56             | 0.18            | 0.13            | 0.30             | 0.17             |
| Control                                                              | 0.07             | 0.24             | 0.2              | 0.58             | 0.19            | 0.17            | 0.32             | 0.14             |
| (se on diff)                                                         | (0.01)           | (0.02)           | (0.02)           | (0.03)           | (0.03)          | (0.03)          | (0.03)           | (0.03)           |
| <b>Black</b>                                                         |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 0.03             | 0.18             | 0.10             | 0.09             | 0.20            | 0.12            | 0.53             | 0.09             |
| Control                                                              | 0.03             | 0.17             | 0.07             | 0.07             | 0.15            | 0.1             | 0.44             | 0.06             |
| (se on diff)                                                         | (0.01)           | (0.02)           | (0.02)           | (0.02)           | (0.03)          | (0.03)          | (0.03)           | (0.02)           |
| <b>Lagged earnings, 1 quarter before treatment</b>                   |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 457              | 388              | 329              | 478              | 332             | 487             | 333              | 514              |
| Control                                                              | 432              | 380              | 359              | 548              | 381             | 449             | 447              | 666              |
| (se on diff)                                                         | (54)             | (44)             | (53)             | (74)             | (93)            | (110)           | (59)             | (97)             |
| <b>Lagged earnings, 2 quarters before treatment</b>                  |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 616              | 498              | 442              | 592              | 471             | 627             | 409              | 647              |
| Control                                                              | 551              | 500              | 491              | 718              | 489             | 684             | 513              | 779              |
| (se on diff)                                                         | (67)             | (51)             | (63)             | (83)             | (101)           | (131)           | (70)             | (110)            |
| <b>Average quarterly post-treatment earnings</b>                     |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment                                                            | 657              | 642              | 642              | 693              | 560             | 811             | 562              | 730              |
| Control                                                              | 478              | 501              | 445              | 532              | 348             | 617             | 603              | 690              |
| (se on diff)                                                         | (57)             | (42)             | (55)             | (66)             | (82)            | (117)           | (70)             | (94)             |
| <b>Average quarterly treatment impact, conditional on covariates</b> |                  |                  |                  |                  |                 |                 |                  |                  |
| Treatment effect                                                     | 145              | 149              | 149              | 190              | 292             | 213             | 21               | 49               |
| (se)                                                                 | (50)             | (39)             | (39)             | (56)             | (72)            | (109)           | (64)             | (90)             |

Table 2 (cont'd): Site Characteristics from the GAIN Experiment

| Variable<br>(sample<br>size)                                         | San Diego       |                   |                   |                   |                  |                  | Tulare           |                   |
|----------------------------------------------------------------------|-----------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|-------------------|
|                                                                      | Site 9<br>(678) | Site 10<br>(1853) | Site 11<br>(2111) | Site 12<br>(1897) | Site 13<br>(630) | Site 14<br>(500) | Site 15<br>(531) | Site 16<br>(1060) |
| <b>Number of children</b>                                            |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 2.34            | 2.34              | 2.57              | 2.34              | 3.92             | 2.87             | 3.03             | 3.04              |
| Control                                                              | 2.42            | 2.4               | 2.77              | 2.39              | 4.44             | 3.02             | 3.33             | 3.05              |
| (se on diff)                                                         | (0.15)          | (0.1)             | (0.1)             | (0.09)            | (0.25)           | (0.19)           | (0.2)            | (0.14)            |
| <b>Reading test score</b>                                            |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 232             | 231               | 231               | 231               | 231              | 230              | 232              | 231               |
| Control                                                              | 227             | 228               | 229               | 228               | 228              | 227              | 226              | 228               |
| (se on diff)                                                         | (4.63)          | (2.81)            | (2.59)            | (3.35)            | (2.61)           | (2.7)            | (5.47)           | (3.23)            |
| <b>Grade</b>                                                         |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 11.56           | 11.34             | 10.39             | 11.35             | 6.45             | 9.63             | 9.45             | 9.47              |
| Control                                                              | 11.45           | 11.63             | 10.31             | 11.15             | 7.03             | 9.5              | 9.21             | 9.38              |
| (se on diff)                                                         | (0.21)          | (0.15)            | (0.18)            | (0.12)            | (0.44)           | (0.32)           | (0.33)           | (0.22)            |
| <b>Previous training experience</b>                                  |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 0.03            | 0.08              | 0.11              | 0.13              | 0.12             | 0.06             | 0.25             | 0.25              |
| Control                                                              | 0.04            | 0.11              | 0.1               | 0.16              | 0.12             | 0.08             | 0.22             | 0.2               |
| (se on diff)                                                         | (0.02)          | (0.02)            | (0.02)            | (0.02)            | (0.03)           | (0.03)           | (0.04)           | (0.03)            |
| <b>Hispanic</b>                                                      |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 0.2             | 0.17              | 0.55              | 0.09              | 0                | 0.62             | 0.43             | 0.34              |
| Control                                                              | 0.14            | 0.17              | 0.51              | 0.12              | 0                | 0.63             | 0.49             | 0.29              |
| (se on diff)                                                         | (0.04)          | (0.02)            | (0.03)            | (0.02)            | (0)              | (0.05)           | (0.05)           | (0.03)            |
| <b>Black</b>                                                         |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 0.27            | 0.33              | 0.12              | 0.08              | 0                | 0.01             | 0                | 0.01              |
| Control                                                              | 0.27            | 0.34              | 0.15              | 0.06              | 0                | 0.01             | 0.01             | 0.01              |
| (se on diff)                                                         | (0.04)          | (0.03)            | (0.02)            | (0.02)            | (0.01)           | (0.01)           | (0.01)           | (0.01)            |
| <b>Lagged earnings, 1 quarter before treatment</b>                   |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 536             | 456               | 493               | 498               | 298              | 476              | 573              | 439               |
| Control                                                              | 470             | 382               | 531               | 558               | 234              | 527              | 366              | 440               |
| (se on diff)                                                         | (116)           | (70)              | (70)              | (66)              | (55)             | (103)            | (103)            | (67)              |
| <b>Lagged earnings, 2 quarters before treatment</b>                  |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 644             | 533               | 557               | 608               | 321              | 603              | 665              | 521               |
| Control                                                              | 524             | 493               | 729               | 721               | 205              | 513              | 435              | 530               |
| (se on diff)                                                         | (124)           | (81)              | (74)              | (77)              | (60)             | (104)            | (112)            | (74)              |
| <b>Average quarterly post-treatment earnings</b>                     |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment                                                            | 703             | 689               | 696               | 744               | 414              | 610              | 612              | 530               |
| Control                                                              | 531             | 496               | 715               | 676               | 455              | 641              | 515              | 444               |
| (se on diff)                                                         | (112)           | (72)              | (71)              | (70)              | (84)             | (96)             | (87)             | (61)              |
| <b>Average quarterly treatment impact, conditional on covariates</b> |                 |                   |                   |                   |                  |                  |                  |                   |
| Treatment effect                                                     | 116             | 195               | 39                | 104               | -90              | -15              | 25               | 80                |
| (se)                                                                 | (104)           | (65)              | (62)              | (65)              | (77)             | (87)             | (77)             | (53)              |

Table 2 (cont'd): Site Characteristics from the GAIN Experiment

|                                                                      | Tulare           |                  | Alameda           |                  | Los Angeles      |                   |                   |                  |
|----------------------------------------------------------------------|------------------|------------------|-------------------|------------------|------------------|-------------------|-------------------|------------------|
| Variable<br>(sample<br>size)                                         | Site 17<br>(864) | Site 18<br>(880) | Site 19<br>(1360) | Site 20<br>(835) | Site 21<br>(842) | Site 22<br>(1485) | Site 23<br>(1888) | Site 24<br>(800) |
| <b>Number of children</b>                                            |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 2.98             | 3.04             | 2.38              | 3.54             | 4.20             | 3.21              | 3.72              | 3.73             |
| Control                                                              | 3.05             | 3.06             | 2.39              | 3.44             | 4.45             | 3.25              | 4.07              | 3.84             |
| (se on diff)                                                         | (0.15)           | (0.14)           | (0.09)            | (0.16)           | (0.18)           | (0.12)            | (0.11)            | (0.17)           |
| <b>Reading test score</b>                                            |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 232              | 231              | 231               | 232              | 230              | 230               | 231               | 231              |
| Control                                                              | 226              | 228              | 228               | 223              | 228              | 227               | 229               | 228              |
| (se on diff)                                                         | (6.29)           | (3.85)           | (3.01)            | (8.63)           | (2.32)           | (3.68)            | (1.5)             | (3.13)           |
| <b>Grade</b>                                                         |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 10.08            | 9.91             | 10.78             | 9.36             | 7.84             | 9.54              | 9.69              | 7.61             |
| Control                                                              | 10.36            | 9.77             | 10.8              | 9.55             | 7.38             | 9.17              | 9.49              | 7.39             |
| (se on diff)                                                         | (0.2)            | (0.26)           | (0.16)            | (0.25)           | (0.27)           | (0.2)             | (0.17)            | (0.29)           |
| <b>Previous training experience</b>                                  |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 0.26             | 0.12             | 0.23              | 0.2              | 0.11             | 0.05              | 0.17              | 0.16             |
| Control                                                              | 0.19             | 0.11             | 0.25              | 0.14             | 0.12             | 0.05              | 0.15              | 0.17             |
| (se on diff)                                                         | (0.03)           | (0.02)           | (0.02)            | (0.03)           | (0.02)           | (0.01)            | (0.02)            | (0.03)           |
| <b>Hispanic</b>                                                      |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 0.40             | 0.36             | 0.09              | 0.40             | 0.28             | 0.22              | 0.15              | 0.78             |
| Control                                                              | 0.38             | 0.38             | 0.06              | 0.30             | 0.24             | 0.18              | 0.16              | 0.73             |
| (se on diff)                                                         | (0.04)           | (0.04)           | (0.01)            | (0.03)           | (0.03)           | (0.02)            | (0.02)            | (0.03)           |
| <b>Black</b>                                                         |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 0.11             | 0.02             | 0.63              | 0.11             | 0.09             | 0.47              | 0.64              | 0.06             |
| Control                                                              | 0.09             | 0.03             | 0.65              | 0.13             | 0.07             | 0.41              | 0.56              | 0.06             |
| (se on diff)                                                         | (0.02)           | (0.01)           | (0.03)            | (0.02)           | (0.02)           | (0.03)            | (0.02)            | (0.02)           |
| <b>Lagged earnings, 1 quarter before treatment</b>                   |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 403              | 544              | 139               | 136              | 178              | 175               | 165               | 62               |
| Control                                                              | 597              | 475              | 145               | 160              | 199              | 173               | 146               | 137              |
| (se on diff)                                                         | (74)             | (100)            | (33)              | (34)             | (31)             | (33)              | (30)              | (33)             |
| <b>Lagged earnings, 2 quarters before treatment</b>                  |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 504              | 598              | 118               | 145              | 193              | 179               | 139               | 67               |
| Control                                                              | 716              | 518              | 141               | 157              | 178              | 162               | 121               | 152              |
| (se on diff)                                                         | (92)             | (104)            | (30)              | (36)             | (34)             | (32)              | (26)              | (37)             |
| <b>Average quarterly post-treatment earnings</b>                     |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment                                                            | 558              | 558              | 377               | 381              | 340              | 301               | 309               | 210              |
| Control                                                              | 691              | 691              | 301               | 301              | 253              | 311               | 299               | 269              |
| (se on diff)                                                         | (75)             | (75)             | (46)              | (52)             | (40)             | (43)              | (36)              | (46)             |
| <b>Average quarterly treatment impact, conditional on covariates</b> |                  |                  |                   |                  |                  |                   |                   |                  |
| Treatment effect                                                     | -18              | -2               | 84                | 108              | 80               | -6                | -7                | -50              |
| (se)                                                                 | (68)             | (62)             | (41)              | (49)             | (37)             | (39)              | (32)              | (44)             |

Table 3: Average Earnings per Person per Quarter, Sites 1-6

|       |                                                                     | Butte   |                   | Riverside         |                   |                   |
|-------|---------------------------------------------------------------------|---------|-------------------|-------------------|-------------------|-------------------|
| Model |                                                                     | Site 1  | Site 2            | Site 3            | Site 4            |                   |
| (1)   | Pooled                                                              | Treated | 614<br>[601,628]  | 562<br>[552,572]  | 535<br>[522,548]  | 564<br>[548,580]  |
|       |                                                                     | Control | 499<br>[485,512]  | 446<br>[436,457]  | 422<br>[410,434]  | 464<br>[449,479]  |
| (2)   | Separate                                                            | Treated | 533<br>[512,555]  | 604<br>[587,622]  | 596<br>[573,619]  | 672<br>[644,702]  |
|       |                                                                     | Control | 407<br>[384,431]  | 421<br>[403,441]  | 366<br>[344,388]  | 483<br>[452,515]  |
| (3)   | Hierarchical,<br>no smoothing                                       | Treated | 533<br>[513,555]  | 605<br>[586,623]  | 595<br>[570,620]  | 672<br>[644,703]  |
|       |                                                                     | Control | 407<br>[386,430]  | 422<br>[401,442]  | 365<br>[344,389]  | 485<br>[453,519]  |
| (4)   | Hierarchical,<br>smoothed                                           | Treated | 590<br>[571,609]  | 543<br>[531,555]  | 523<br>[510,539]  | 571<br>[552,590]  |
|       |                                                                     | Control | 436<br>[418,456]  | 417<br>[405,429]  | 409<br>[395,423]  | 500<br>[479,520]  |
| (5)   | Alameda<br>participants<br>in other sites                           | Treated | 401<br>[383,418]  | 525<br>[505,544]  | 545<br>[524,567]  | 538<br>[514,561]  |
|       |                                                                     | Control | 335<br>[312,356]  | 354<br>[334,374]  | 306<br>[284,327]  | 333<br>[308,361]  |
| (5)   | Hierarchical,<br>predicting<br>site effects                         | Treated | 589<br>[365,1289] | 510<br>[321,1282] | 489<br>[276,1251] | 553<br>[347,1305] |
|       |                                                                     | Control | 444<br>[221,1371] | 400<br>[204,1376] | 387<br>[187,1203] | 495<br>[254,1358] |
| (6)   | Predicting<br>site effects,<br>dropping obs.<br>from that site      | Treated | 609<br>[311,2302] | 502<br>[293,2015] | 477<br>[283,2045] | 537<br>[330,2016] |
|       |                                                                     | Control | 458<br>[215,3262] | 397<br>[185,2442] | 390<br>[195,2598] | 501<br>[251,2857] |
| (7)   | Predicting<br>site effects,<br>dropping obs.<br>from that<br>county | Treated | 609<br>[343,1936] | 479<br>[2,7408]   | 456<br>[0,7422]   | 536<br>[1,7693]   |
|       |                                                                     | Control | 458<br>[238,2142] | 410<br>[6,3570]   | 396<br>[6,3793]   | 501<br>[6,3895]   |

Note: The table presents the mean and 2.5 and 97.5 percentiles of the predictive distribution of average earnings per person per quarter. In rows 1 to 4 and rows 5 to 7, earnings are predicted for the original treatment and control participants at each site, under the specified models. In row 4, earnings are predicted for the Alameda treatment and control participants, if they had been located at the specified site.

Table 3 (cont'd): Average Earnings per Person per Quarter, Sites 5-8

|       |                                                                     | Riverside  |            | San Diego  |            |            |
|-------|---------------------------------------------------------------------|------------|------------|------------|------------|------------|
| Model |                                                                     | Site 5     | Site 6     | Site 7     | Site 8     |            |
| (1)   | Pooled                                                              | Treated    | 567        | 649        | 535        | 652        |
|       |                                                                     |            | [547,586]  | [629,670]  | [519,550]  | [635,672]  |
|       |                                                                     | Control    | 447        | 518        | 424        | 527        |
|       |                                                                     | [428,467]  | [498,539]  | [410,436]  | [509,543]  |            |
| (2)   | Separate                                                            | Treated    | 566        | 728        | 480        | 613        |
|       |                                                                     |            | [525,608]  | [683,772]  | [456,505]  | [581,648]  |
|       |                                                                     | Control    | 343        | 559        | 440        | 563        |
|       |                                                                     | [302,384]  | [499,620]  | [409,470]  | [521,605]  |            |
| (3)   | Hierarchical,<br>no smoothing                                       | Treated    | 563        | 726        | 481        | 611        |
|       |                                                                     |            | [525,605]  | [684,772]  | [455,507]  | [579,644]  |
|       |                                                                     | Control    | 342        | 558        | 442        | 560        |
|       |                                                                     | [304,382]  | [506,611]  | [412,477]  | [511,603]  |            |
| (4)   | Hierarchical,<br>smoothed                                           | Treated    | 556        | 623        | 497        | 685        |
|       |                                                                     |            | [535,578]  | [597,650]  | [480,512]  | [658,712]  |
|       |                                                                     | Control    | 420        | 470        | 385        | 544        |
|       |                                                                     | [400,441]  | [444,494]  | [368,402]  | [516,570]  |            |
| (5)   | Alameda<br>participants<br>in other sites                           | Treated    | 483        | 536        | 418        | 494        |
|       |                                                                     |            | [449,515]  | [508,562]  | [400,436]  | [472,518]  |
|       |                                                                     | Control    | 263        | 365        | 371        | 435        |
|       |                                                                     | [233,293]  | [327,406]  | [344,399]  | [398,475]  |            |
| (5)   | Hierarchical,<br>predicting<br>site effects                         | Treated    | 507        | 644        | 485        | 689        |
|       |                                                                     |            | [282,1229] | [384,1383] | [293,1187] | [369,1382] |
|       |                                                                     | Control    | 392        | 451        | 386        | 514        |
|       |                                                                     | [193,1219] | [187,1511] | [202,1255] | [227,1375] |            |
| (6)   | Predicting<br>site effects,<br>dropping obs.<br>from that site      | Treated    | 497        | 622        | 489        | 710        |
|       |                                                                     |            | [234,1872] | [303,3070] | [276,2557] | [377,2611] |
|       |                                                                     | Control    | 402        | 431        | 379        | 503        |
|       |                                                                     | [176,2611] | [140,2783] | [168,2607] | [174,3503] |            |
| (7)   | Predicting<br>site effects,<br>dropping obs.<br>from that<br>county | Treated    | 471        | 750        | 494        | 772        |
|       |                                                                     |            | [1,6646]   | [4,6799]   | [3,6407]   | [9,6752]   |
|       |                                                                     | Control    | 407        | 342        | 393        | 392        |
|       |                                                                     | [11,3616]  | [11,2991]  | [13,3123]  | [33,3261]  |            |

Table 3 (cont'd): Average Earnings per Person per Quarter, Sites 9-12

|       |                                                                     | San Diego |                   |                   |                   |                   |
|-------|---------------------------------------------------------------------|-----------|-------------------|-------------------|-------------------|-------------------|
| Model |                                                                     | Site 9    | Site 10           | Site 11           | Site 12           |                   |
| (1)   | Pooled                                                              | Treated   | 644<br>[623,667]  | 599<br>[585,613]  | 586<br>[572,600]  | 641<br>[625,655]  |
|       |                                                                     | Control   | 517<br>[497,537]  | 475<br>[463,488]  | 474<br>[461,486]  | 516<br>[502,530]  |
| (2)   | Separate                                                            | Treated   | 664<br>[619,708]  | 594<br>[570,620]  | 561<br>[537,582]  | 553<br>[531,579]  |
|       |                                                                     | Control   | 557<br>[500,616]  | 467<br>[438,501]  | 506<br>[478,537]  | 465<br>[434,496]  |
| (3)   | Hierarchical,<br>no smoothing                                       | Treated   | 666<br>[622,712]  | 596<br>[573,618]  | 562<br>[540,586]  | 554<br>[531,578]  |
|       |                                                                     | Control   | 558<br>[499,615]  | 466<br>[435,500]  | 507<br>[475,537]  | 465<br>[436,494]  |
| (4)   | Hierarchical,<br>smoothed                                           | Treated   | 641<br>[614,667]  | 560<br>[544,576]  | 576<br>[561,592]  | 623<br>[608,640]  |
|       |                                                                     | Control   | 502<br>[474,530]  | 413<br>[397,430]  | 486<br>[469,504]  | 479<br>[462,498]  |
| (5)   | Alameda<br>participants<br>in other sites                           | Treated   | 527<br>[499,557]  | 472<br>[454,492]  | 479<br>[463,496]  | 472<br>[453,492]  |
|       |                                                                     | Control   | 357<br>[318,396]  | 323<br>[299,350]  | 416<br>[386,446]  | 403<br>[373,432]  |
| (5)   | Hierarchical,<br>predicting<br>site effects                         | Treated   | 649<br>[404,1471] | 547<br>[311,1474] | 550<br>[333,1366] | 616<br>[348,1367] |
|       |                                                                     | Control   | 475<br>[225,1547] | 392<br>[186,1477] | 457<br>[221,1499] | 453<br>[217,1550] |
| (6)   | Predicting<br>site effects,<br>dropping obs.<br>from that site      | Treated   | 645<br>[276,2389] | 542<br>[289,2594] | 545<br>[277,2307] | 624<br>[297,2131] |
|       |                                                                     | Control   | 459<br>[183,2431] | 385<br>[159,3055] | 447<br>[213,2964] | 451<br>[167,2014] |
| (7)   | Predicting<br>site effects,<br>dropping obs.<br>from that<br>county | Treated   | 738<br>[8,6835]   | 613<br>[7,7088]   | 572<br>[2,6570]   | 686<br>[6,6524]   |
|       |                                                                     | Control   | 355<br>[22,2819]  | 354<br>[29,3019]  | 369<br>[20,3209]  | 376<br>[16,2619]  |

Table 3 (cont'd): Average Earnings per Person per Quarter, Sites 13-16

|                                                                         |         | San Diego         |                   | Tulare            |                   |
|-------------------------------------------------------------------------|---------|-------------------|-------------------|-------------------|-------------------|
| Model                                                                   |         | Site 13           | Site 14           | Site 15           | Site 16           |
| (1) Pooled                                                              | Treated | 410<br>[390,428]  | 601<br>[577,625]  | 581<br>[556,607]  | 560<br>[542,575]  |
|                                                                         | Control | 344<br>[327,362]  | 504<br>[480,527]  | 480<br>[458,503]  | 460<br>[445,477]  |
| (2) Separate                                                            | Treated | 561<br>[520,601]  | 620<br>[570,668]  | 585<br>[545,629]  | 488<br>[456,522]  |
|                                                                         | Control | 620<br>[556,689]  | 637<br>[574,701]  | 534<br>[481,592]  | 423<br>[393,459]  |
| (3) Hierarchical,<br>no smoothing                                       | Treated | 561<br>[522,602]  | 614<br>[564,666]  | 584<br>[540,632]  | 489<br>[460,520]  |
|                                                                         | Control | 617<br>[555,686]  | 630<br>[564,689]  | 537<br>[482,595]  | 423<br>[388,456]  |
| (4) Hierarchical,<br>smoothed                                           | Treated | 525<br>[489,563]  | 640<br>[606,674]  | 618<br>[593,648]  | 554<br>[533,576]  |
|                                                                         | Control | 547<br>[499,592]  | 538<br>[500,576]  | 561<br>[530,590]  | 488<br>[465,510]  |
| (5) Alameda<br>participants<br>in other sites                           | Treated | 487<br>[453,522]  | 445<br>[412,480]  | 398<br>[368,431]  | 403<br>[377,431]  |
|                                                                         | Control | 749<br>[664,845]  | 439<br>[390,487]  | 403<br>[360,449]  | 316<br>[286,350]  |
| (5) Hierarchical,<br>predicting<br>site effects                         | Treated | 528<br>[263,1474] | 670<br>[452,1306] | 598<br>[374,1111] | 498<br>[325,1072] |
|                                                                         | Control | 641<br>[326,2082] | 604<br>[348,1613] | 548<br>[318,1615] | 480<br>[270,1416] |
| (6) Predicting<br>site effects,<br>dropping obs.<br>from that site      | Treated | 485<br>[191,4007] | 740<br>[407,2786] | 602<br>[368,2141] | 501<br>[291,2531] |
|                                                                         | Control | 886<br>[180,8996] | 592<br>[223,3964] | 555<br>[260,2964] | 505<br>[274,3152] |
| (7) Predicting<br>site effects,<br>dropping obs.<br>from that<br>county | Treated | 476 [5,5153]      | 735<br>[4,6881]   | 640<br>[2,7844]   | 550<br>[2,7287]   |
|                                                                         | Control | 839<br>[76,3840]  | 598<br>[22,4287]  | 578<br>[10,4250]  | 534<br>[12,4423]  |

Table 3 (cont'd): Average Earnings per Person per Quarter, Sites 17-20

|       |                                                                     | Tulare  |                   | Alameda           | Los Angeles       |                   |
|-------|---------------------------------------------------------------------|---------|-------------------|-------------------|-------------------|-------------------|
| Model |                                                                     | Site 17 | Site 18           | Site 19           | Site 20           |                   |
| (1)   | Pooled                                                              | Treated | 600<br>[582,622]  | 581<br>[561,601]  | 453<br>[439,466]  | 401<br>[384,418]  |
|       |                                                                     | Control | 491<br>[472,510]  | 469<br>[450,487]  | 337<br>[326,350]  | 297<br>[283,311]  |
| (2)   | Separate                                                            | Treated | 510<br>[476,542]  | 516<br>[483,547]  | 282<br>[259,303]  | 323<br>[294,350]  |
|       |                                                                     | Control | 530<br>[488,571]  | 509<br>[473,545]  | 227<br>[209,246]  | 251<br>[226,277]  |
| (3)   | Hierarchical,<br>no smoothing                                       | Treated | 513<br>[480,548]  | 519<br>[485,552]  | 282<br>[262,300]  | 322<br>[293,349]  |
|       |                                                                     | Control | 530<br>[492,566]  | 513<br>[475,553]  | 226<br>[209,243]  | 251<br>[224,277]  |
| (4)   | Hierarchical,<br>smoothed                                           | Treated | 596<br>[576,620]  | 585<br>[563,605]  | 343<br>[322,364]  | 303<br>[284,321]  |
|       |                                                                     | Control | 524<br>[497,548]  | 506<br>[488,525]  | 268<br>[251,286]  | 254<br>[236,271]  |
| (5)   | Alameda<br>participants<br>in other sites                           | Treated | 361<br>[336,385]  | 387<br>[361,411]  | 281<br>[260,301]  | 367<br>[337,399]  |
|       |                                                                     | Control | 383<br>[347,416]  | 370<br>[337,404]  | 226<br>[208,244]  | 282<br>[256,309]  |
| (5)   | Hierarchical,<br>predicting<br>site effects                         | Treated | 536<br>[362,1138] | 550<br>[376,1224] | 314<br>[191,725]  | 303<br>[175,779]  |
|       |                                                                     | Control | 514<br>[313,1498] | 481<br>[278,1562] | 286<br>[143,991]  | 241<br>[140,1011] |
| (6)   | Predicting<br>site effects,<br>dropping obs.<br>from that site      | Treated | 543<br>[307,1983] | 555<br>[338,1987] | 501<br>[174,5522] | 298<br>[149,1834] |
|       |                                                                     | Control | 511<br>[249,2663] | 478<br>[268,2696] | 717<br>[332,4635] | 238<br>[117,2948] |
| (7)   | Predicting<br>site effects,<br>dropping obs.<br>from that<br>county | Treated | 595<br>[2,7591]   | 589<br>[2,7942]   | 314<br>[178,879]  | 894<br>[5,9228]   |
|       |                                                                     | Control | 570<br>[7,4855]   | 516<br>[15,4442]  | 286<br>[132,881]  | 579<br>[40,3840]  |

Table 3 (cont'd): Average Earnings per Person per Quarter, Sites 21-24

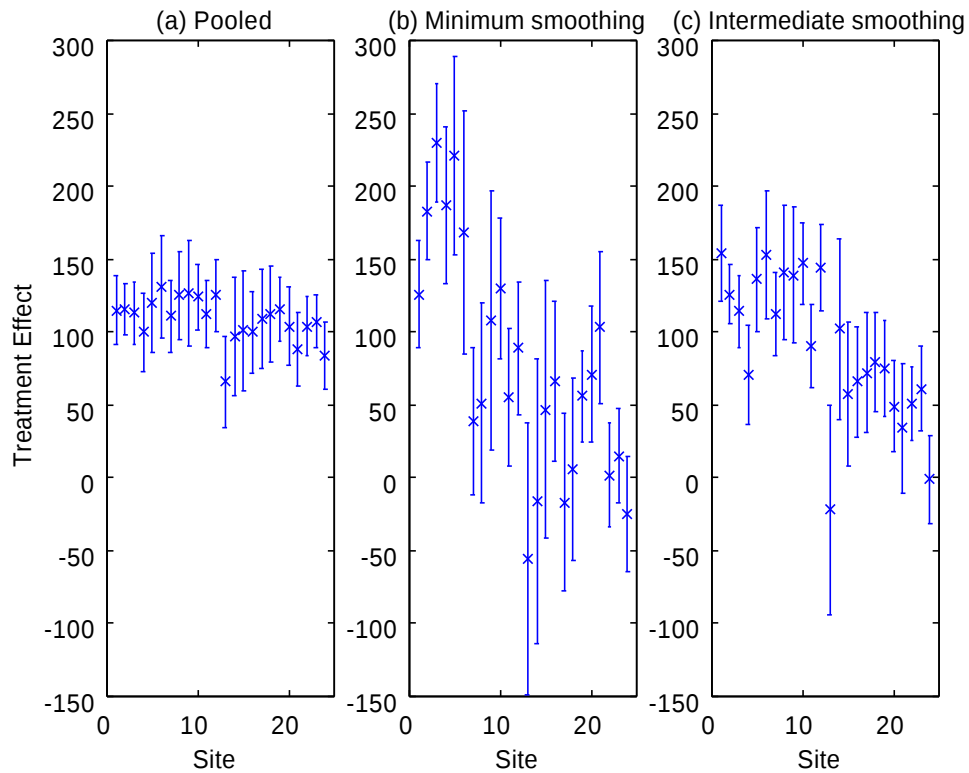
|                                                             |         | Los Angeles        |                   |                   |                  |
|-------------------------------------------------------------|---------|--------------------|-------------------|-------------------|------------------|
| Model                                                       |         | Site 21            | Site 22           | Site 23           | Site 24          |
| (1) Pooled Tobit                                            | Treated | 387<br>[371,402]   | 413<br>[401,426]  | 403<br>[392,415]  | 307<br>[294,323] |
|                                                             | Control | 299<br>[286,314]   | 309<br>[298,321]  | 296<br>[286,305]  | 223<br>[211,236] |
| (2) Site-by-site Tobit                                      | Treated | 427<br>[394,460]   | 289<br>[269,307]  | 303<br>[286,321]  | 175<br>[156,195] |
|                                                             | Control | 324<br>[297,352]   | 285<br>[263,307]  | 286<br>[268,306]  | 200<br>[176,224] |
| (3) Hierarchical, no smoothing                              | Treated | 426<br>[394,460]   | 288<br>[268,308]  | 303<br>[284,322]  | 175<br>[154,197] |
|                                                             | Control | 323<br>[295,349]   | 286<br>[265,307]  | 288<br>[270,307]  | 200<br>[178,227] |
| (4) Hierarchical, smoothed                                  | Treated | 418<br>[393,444]   | 325<br>[310,339]  | 339<br>[322,357]  | 197<br>[179,212] |
|                                                             | Control | 384<br>[358,411]   | 274<br>[260,289]  | 278<br>[263,295]  | 198<br>[180,217] |
| (5) Alameda participants in other sites                     | Treated | 455<br>[419,497]   | 274<br>[257,294]  | 361<br>[341,384]  | 267<br>[239,296] |
|                                                             | Control | 282<br>[250,316]   | 315<br>[290,340]  | 332<br>[310,356]  | 275<br>[240,309] |
| (5) Hierarchical, predicting site effects                   | Treated | 447<br>[290,1134]  | 312<br>[189,805]  | 324<br>[188,858]  | 175<br>[96,483]  |
|                                                             | Control | 397<br>[188,1716]  | 246<br>[152,972]  | 257<br>[138,1045] | 184<br>[90,1020] |
| (6) Predicting site effects, dropping obs. from that site   | Treated | 487<br>[276,3258]  | 321<br>[175,1582] | 371<br>[150,3694] | 181<br>[93,3049] |
|                                                             | Control | 532<br>[271,5806]  | 237<br>[119,2230] | 218<br>[107,3402] | 177<br>[71,4930] |
| (7) Predicting site effects, dropping obs. from that county | Treated | 1483<br>[12,8219]  | 796<br>[4,8013]   | 652<br>[1,8072]   | 931<br>[4,8998]  |
|                                                             | Control | 1201<br>[151,4040] | 508<br>[39,3050]  | 451<br>[26,4224]  | 934<br>[96,3974] |

Table 4: Explanatory Power of County Dummies Conditional on Site Characteristics

| Variable                                      | Adjusted $R^2$ of County<br>Dummies<br>(0.025 and 97.5<br>percentiles) |
|-----------------------------------------------|------------------------------------------------------------------------|
| Constant                                      | -0.1768<br>[-0.2195,-0.0954]                                           |
| Number of Children                            | 0.0020<br>[-0.1250,0.1436]                                             |
| Education                                     | -0.0458<br>[-0.1178,0.0551]                                            |
| Age                                           | -0.1150<br>[-0.2048,0.0228]                                            |
| $1(\text{Earnings}_{t=2}=0)$                  | -0.1322<br>[-0.2030,-0.0304]                                           |
| $\log(\text{Earnings}_{t=2}+1)$               | -0.1117<br>[-0.1954,0.0022]                                            |
| $1(\text{Earnings}_{t=1}=0)$                  | -0.1429<br>[-0.2028,-0.0369]                                           |
| $\log(\text{Earnings}_{t=1}+1)$               | -0.1177<br>[-0.1918,0.0120]                                            |
| Time trend                                    | 0.0486<br>[-0.0740,0.1855]                                             |
| Constant·Treatment                            | -0.1086<br>[-0.1941,-0.0105]                                           |
| Number of<br>Children·Treatment               | -0.0800<br>[-0.1662,0.0258]                                            |
| Education·Treatment                           | -0.0050<br>[-0.0940,0.0983]                                            |
| Age·Treatment                                 | -0.1153<br>[-0.1903,-0.0140]                                           |
| $1(\text{Earnings}_{t=2}=0)$<br>·Treatment    | -0.1412<br>[-0.2079,-0.0303]                                           |
| $\log(\text{Earnings}_{t=2}+1)$<br>·Treatment | -0.1161<br>[-0.2017,0.0170]                                            |

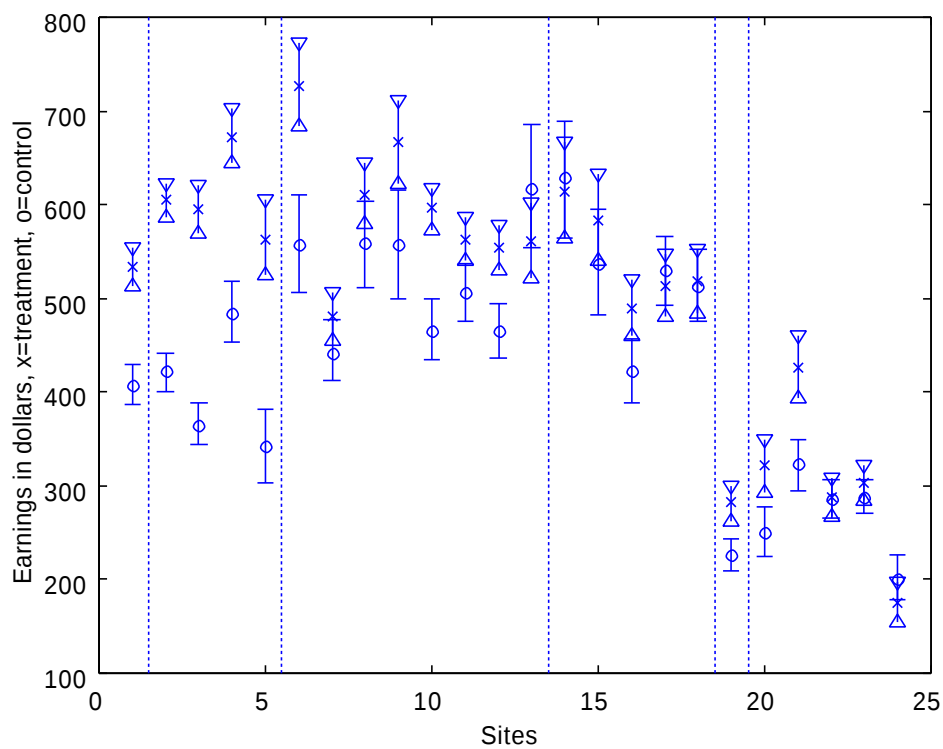
Note: The table presents the mean and 2.5 and 97.5 percentiles of the predictive distribution of the adjusted  $R^2$  of a regression of site coefficients on county-level dummies.

Figure 1: Average Treatment Impact per Person per Quarter



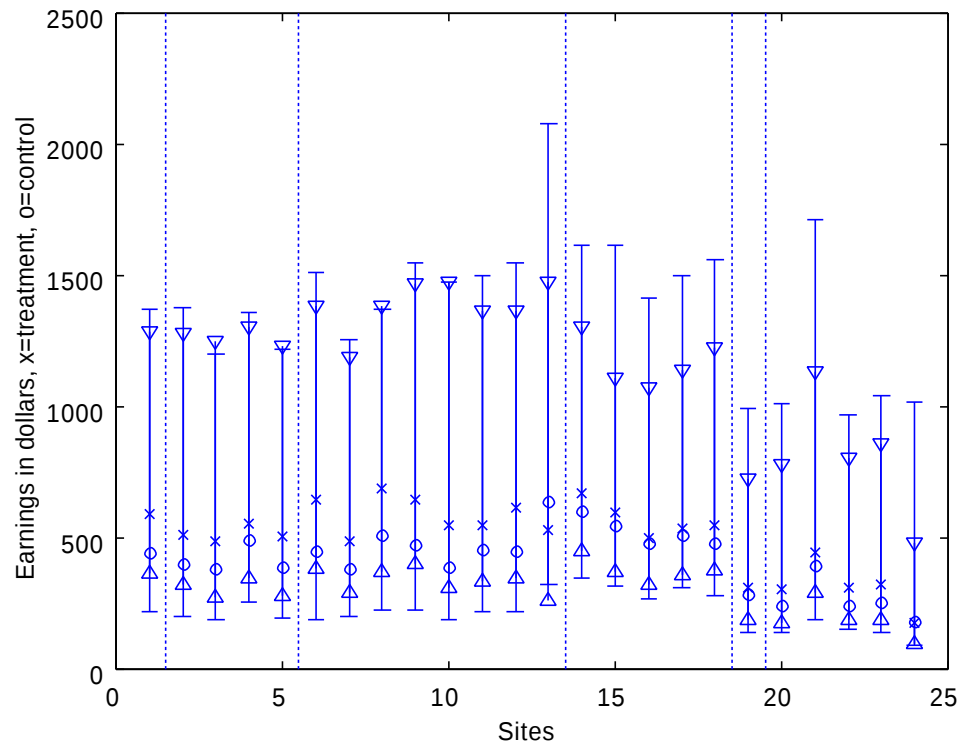
Note: The figure depicts the mean and 2.5 and 97.5 percentiles of the predictive distribution of the average treatment effect per person per quarter at each site under the specified models. Panel (a) corresponds to Table 3, columns (1) and (2); Panel (b) to Table 3, columns (5) and (6); and Panel (c) to Table 3, columns (7) and (8).

Figure 2: Average Treatment and Control Earnings per Person per Quarter Given Site Effects



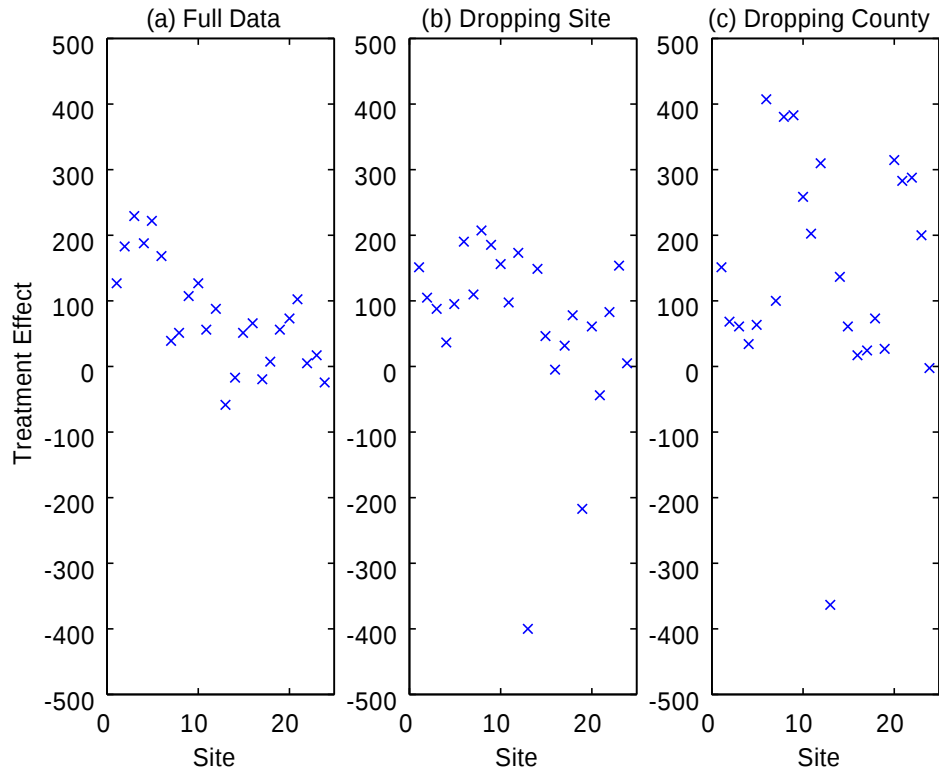
Note: The figure depicts the mean and 2.5 and 97.5 percentiles of the predictive distribution of average treatment and control earnings per person per quarter at each site. The model takes the profile of site effects as given. The figure corresponds to Table 3, columns (5) and (6).

Figure 3: Average Treatment and Control Earnings per Person per Quarter Predicting Site Effects



Note: The figure depicts the mean and 2.5 and 97.5 percentiles of the predictive distribution of average treatment and control earnings per person per quarter at each site, redrawing for site effects based on the hierarchical model. The figure corresponds to Table 4, columns (3) and (4).

Figure 4: Average Treatment Impact per Person per Quarter



Note: The figure depicts the mean of the predictive distribution of the average treatment effect per person per quarter at each site under the specified models. Panel (a) corresponds to Table 3, columns (5) and (6); Panel (b) to Table 6, columns (1) and (2); and Panel (c) to Table 6, columns (3) and (4).