

Appendix B

More Difference-in-Differences Bias Issues

We already noted that our DD estimators would be unbiased estimators of the ATT if and only if various data and modeling assumptions held. However, even if all the DD data and modeling assumptions held, there would be other reasons to suspect that the DD estimators generated by models (1) and (3) are biased. We detail some of the other potential sources of DD estimator bias here.

As we mentioned in the introduction, the establishment of CH boundaries is guided by the spatial distribution of the species and known habitat. Within that area,

where a landowner seeks or requests Federal agency funding or authorization for an action that may affect a listed species or critical habitat, the consultation requirements of section 7(a)(2) would apply, but even in the event of a destruction or adverse modification finding, the obligation of the Federal action agency and the landowner is not to restore or recover the species, but to implement reasonable and prudent alternatives to avoid destruction or adverse modification of critical habitat. (p. 2542, USDOIFWS 2013)

We have hypothesized that the consultation requirement and the possibility of a “destruction or adverse modification finding” dampens developer demand for land in the CH, all else equal, and, accordingly, dampens prices for those lands, all else equal. However, a more nuanced model of CH’s impact on undeveloped parcel values would surmise that *only some* developable parcels would be likely to require the developer to “implement reasonable and prudent alternatives to avoid destruction or adverse modification of critical habitat” and that these specific parcels would be especially undesirable relative to those “treated” parcels that were unlikely to engender a destruction or adverse-modification finding when subject to a development plan. Therefore, a critical unobserved variable in our analysis of undeveloped parcel prices indicates each parcel’s probability of a destruction or adverse-modification finding if considered for development. Let this probability be given by M_{jt} . Model (1) with this omitted variable is

$$V_{jt} = f(\varphi, \sigma, \gamma, Z_j) + \delta 1[T]_j + \theta 1[A]_{jt} + \varphi 1[T]_j 1[A]_{jt} + \rho M_{jt} + \epsilon_{jt}. \quad (\text{SI } 1)$$

If $\text{cov}(M_{jt}, 1[T]_j) \neq 0$, then model (1)’s μ for an undeveloped parcel is a biased DD estimator of the undeveloped parcel’s “true” DD estimator φ . Suppose the form of covariance between M_{jt} and $1[T]_j$ can be represented with the following equation:

$$M_{jt} = a + b 1[T]_j + c 1[T]_j 1[A]_{jt} + \epsilon_{jt} \quad (\text{SI } 2)$$

Then (SI 1) becomes,

$$V_{jt} = f(\varphi, \sigma, \gamma, Z_j) + \delta 1[T]_j + \theta 1[A]_{jt} + \varphi 1[T]_j 1[A]_{jt} + \rho(a + b 1[T]_j + c 1[T]_j 1[A]_{jt} + \varepsilon_{jt}) + \epsilon_{jt} \quad (\text{SI 3})$$

$$= f(\varphi, \sigma, \gamma, Z_j) + \rho a + (\rho b + \delta) 1[T]_j + \theta 1[A]_{jt} + (\rho c + \varphi) 1[T]_j 1[A]_{jt} + (\rho \varepsilon_{jt} + \epsilon_{jt}). \quad (\text{SI 4})$$

Therefore, model (1)'s $\hat{\mu}$ is an estimate of $\rho c + \varphi$ when $cov(M_{jt}, 1[T]_j) \neq 0$. If we assume

- the value of an undeveloped parcel declines as the likelihood of a destruction or adverse-modification finding on the parcel increases, all else equal ($\rho < 0$); and
- $cov(M_{jt}, 1[T]_j) < 0$ given the FWS's documented efforts to exempt some developable parcels from CH regulation that are likely to otherwise have a destruction or adverse-modification finding ($c < 0$),

then $\hat{\mu}$ will be larger than the “true” DD coefficient φ when $cov(M_{jt}, 1[T]_j) \neq 0$. For example, if $\hat{\mu} = -10.0$ and $\hat{\rho}\hat{c} = 2.0$, then $\hat{\varphi} = -12.0$. In other words, the impact of CH on undeveloped parcel value is likely more negative than we found above when $\hat{\mu} < 0$ and likely less positive than we found above when $\hat{\mu} > 0$.

We do believe that $cov(M_{jt}, 1[T]_j) < 0$ is much more likely than $cov(M_{jt}, 1[T]_j) > 0$. Even though Auffhammer et al. (2020) claim there is no widespread evidence that the FWS significantly modified CH boundaries to reflect economic concerns in two California CHs, we have several reasons to suspect this is not true more generally. First, there are many documented cases of the FWS working with large developers on ESA-compliant habitat-conservation plans and other mitigation strategies to avoid designating their land and projects as CHs (Fosburgh 2022). For example, during the creation of CHs for the Pacific-coast population of the western snowy plover, the FWS worked with Lawson's Landing and Oxfoot Associates to make Dillon Beach in Marin County, California, CH-compliant. In exchange Dillon Beach was not made part of the snowy plover's CH (USDOIFWS 2005). Presumably, the FWS is working with these companies to avoid a likely “destruction or adverse modification finding.” Second, there are some documented cases of slight changes to CH boundaries in response to economic realities. For example:

We modified the boundaries of this critical habitat designation around the City of Gunnison. We refined the boundary to leave out areas of medium to high-intensity development, airport runways, and golf courses. In all other areas, lands covered by

buildings, pavement, and other manmade structures, as of the effective date of this rule, are not included in this designation, even if they occur inside the boundaries of a critical habitat unit, because such lands lack physical and biological features essential to the conservation of Gunnison sage-grouse, and hence do not constitute critical habitat as defined in section 3(5)(A)(i) of the Act. (p. 69313, USDOIFWS 2014)

In other words, FWS regulators appear to be looking for ways to avoid designating areas with high M_{jt} as CHs. Therefore, it is likely that $cov(M_{jt}, 1[T]_j) < 0$ in an unknowable number of cases. And even though using matched-control sales can reduce the potential for omitted variable bias (i.e., if the parcels that are treated tend to have a lower M_{jt} , so would the matched controls if they happened to be treated), it may not eliminate it.