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ARTICLE

Unintended effects of preferential tax assessment on farmland protection: Evidence from Utah's farmland assessment act

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Abstract
This study examines the effect of Utah's Greenbelt program, the state's preferential tax-assessment effort to protect farmland, using an instrumental variable-fixed effects strategy. We find that an unintended effect of the program leads to more conversion of agricultural land to development than the protection it provides. The protection effect is concentrated on parcels with smaller agricultural areas, while conversion occurs on parcels with larger agricultural areas. Our findings shed light on the rationale of a proposed amendment to the policy—Utah House Bill 25—which did not pass during the 2016 legislative session.

KEYWORDS
agricultural land protection, land-use change, land-use policy, preferential tax assessment

JEL CLASSIFICATION
Q15, Q18

1 | INTRODUCTION

Humankind tends to settle on fertile land where crops can be produced (Bryce, 2016; National Aeronautics and Space Administration, 2004). Thus, the most productive soil is often located on peri-urban farmlands, which are in close proximity to urban areas with high population and development densities (Brinkley, 2012; Li et al., 2013; Seto & Kaufmann, 2003). These farmlands consequently experience intense development pressure due to their relatively low current use-value as compared with the value of residential and commercial uses (Brinkley, 2012). To protect

Wai Yan Siu and Man Li contributed equally to this study.

farmland from urban development, various farmland preservation programs (FPPs) have been implemented across the United States (c.f., Fischel, 1982; Wu & Cho, 2007, among others). However, the literature is thin when it comes to measuring the effectiveness of such programs, especially preferential taxation policies.[1] The present study fills this gap by examining the effect of Utah's preferential property tax program, known as the Greenbelt Act, using an instrumental variable (IV)-fixed effects estimation strategy.

This paper assembles a comprehensive annual data set for Salt Lake County, Utah between 2010 and 2018, to assess the effectiveness of Utah's Greenbelt (GB) Act, which taxes farmland according to current use rather than prevailing market value. Salt Lake County is home to the state's largest metropolitan area, Salt Lake City, which has experienced rapid farmland conversion in the past decade, with a significant decline in both the number of farms and average farm size (United States Department of Agriculture, 2019; Supporting Information: Figure A1). The data set is used to estimate the effect of the GB Act on the conversion rate of farmland to residential and commercial development.

The paper makes two main contributions to the literature. First, it evaluates the effects of preferential property tax treatment. Prior research has investigated how FPPs such as agricultural zoning affect land values and purchase of development rights (c.f., Irwin & Bockstael, 2001; Nickerson & Lynch, 2001; Wu & Cho, 2007, among others). The broad acceptance of the GB program in Utah, together with the state's rapid population and employment growth over the past decade (US Bureau of Labor Statistics, 2023), provides an opportunity to study the effectiveness of preferential property tax policy. This paper thus complements a handful of studies that examined the effect of property tax assessments on farmland availability (Morris, 1998), land-use changes (Polyakov & Zhang, 2008), local public finances (Bigelow & Kuethe, 2023), and agricultural productivity loss associated with nonresident ownership (Towe & Chen, 2023).

The paper's second contribution is that, by employing a rigorous research design, it reveals an unintended effect of tax breaks on farmland protection. Utah is among the 10 US states that allow agriculture to be a nonprimary use on a tax-preferred parcel, where the property tax rate of a GB parcel is assessed based on productive agricultural-use value instead of its market value. Findings from this study shed light on the concerns that property owners have exploited this policy design by converting a portion of an agricultural parcel to urban use while maintaining the minimum requirements necessary for ensuring their land retains its GB designation, which could shift the burden of property taxes to other local or state taxpayers (Carman & Polson, 1971; Schoeplein & Schoeplein, 1972, among others), and/or limit the delivery of public services (Bigelow & Kuethe, 2023).

The paper proceeds as follows. Section 2 discusses the economic mechanisms by which the GB Act affects farmland development. Section 3 describes data and methods. Section 4 presents and interprets the empirical results. Section 5 concludes.

2 | MECHANISMS

The monocentric city and urban growth models suggest that bid rent for urban land (i.e., a particular household's ability to pay for land at each location) decreases with distance from a central business district (Alonso, 1964; Mills, 1967; Muth, 1969). As a result, the urban fringe at equilibrium is determined by the coincidence of the equilibrium bid rent and the reservation rent, where the reservation rent includes the rent associated with agricultural use and the opportunity cost of conversion capital (Capozza & Helsley, 1989). The implementation of Utah's GB Act provides an opportunity for the owners of qualifying land parcels to apply for GB designation, which subsequently reduces the annual property tax rate levied on GB parcels and increases the reservation

[1]Although some scholars may consider a short- or medium-term protection of land (such as taxation) a “protection” rather than “preservation” policy, these two terms haven frequently been used interchangeably in the literature.

rent that triggers the conversion of a parcel from agricultural to urban use. Therefore, tax relief under GB designation increases the opportunity cost of land conversion, resulting in the delayed development of GB parcels.

To attain a GB designation, three eligibility criteria must be met on a yearly basis concerning land size, land productivity, and prior years' land use (Utah State Legislature, 1987). The land-size criterion requires that qualifying farmland comprise at least five acres. Farmland that is less than five acres may still qualify if it is devoted to agricultural use and planted in irrigated food crops in conjunction with other eligible land under the same ownership (Office of Legislative Research and General Counsel, 2016). The land-productivity criterion requires that a land parcel meets 50% of the average per-acre agricultural output for the given type and location of the land. The land-use criterion requires that land must have been actively devoted to agricultural use for at least two consecutive years immediately preceding the tax year when land attained GB designation. When a landowner fails to provide evidence that the land meets the eligibility criteria or has been withdrawn from the GB designation, the owner becomes subject to a rollback tax for up to five years. The rollback tax is calculated as the difference between taxes paid while the parcel in question was designated GB, and taxes that would have been paid had the property been assessed at market value (Utah State Tax Commission, 2020). Supporting Information: Table B2 presents a breakdown of GB versus non-GB property tax.

The up-to-5-year rollback tax may undermine the goal of the GB policy, as owners of qualifying parcels may not apply for GB designation if they expect to convert their land to urban use within 5 years. Consequently, parcels located closest to the urban boundary would be less likely to be enrolled in the GB program. In theory, once a parcel is designated as GB, imposing the rollback tax further delays urban development compared to the situation without a rollback tax penalty. The rollback tax acts like a fixed cost of GB designation. The longer a parcel remains designated as GB, the lower the annualized fixed cost. Yet it is difficult to quantify the effect of the rollback tax in isolation because the tax penalty applies to all GB parcels, making what would otherwise be a control group in a controlled or natural experiment (i.e., GB parcels without the rollback tax penalty) nonexistent.

The land-productivity criterion further complicates the relationship between the GB policy and control of urban growth. The agricultural productivity of a parcel must surpass a certain threshold to be eligible for GB tax relief. Yet agricultural productivity is positively correlated with a parcel's reservation rent. It is conceptually ambiguous whether the effect on farmland conservation is driven by GB policy alone or by variation in reservation rent, or both.

More importantly, while the goal of Utah's GB program is to preserve farmland by providing compensation to agricultural landowners, the program does allow non-agriculture to be the primary use of a GB parcel as long as the parcel meets the aforementioned three criteria (Office of Legislative Research and General Counsel, 2016). This has two opposite effects. On the one hand, it motivates rational landowners to convert part of the GB parcel(s) to urban use or to introduce primarily commercial usage in addition to the agricultural usage to maximize the present value of future land rents. Landowners, on the other hand, can keep the remaining eligible land in agriculture and develop it as late as possible, such that the eligible portion of a parcel continues receiving GB tax relief. Consequently, landowners are not necessarily prevented from registering primarily commercial use land for GB designation to take advantage of the program's preferential tax assessment (Brown, 2017; Davidson, 2020; Farm Progress, 2016). This raises concerns about the effectiveness of the GB program in preserving farmland.

3 | DATA AND METHODS

3.1 | Data sources and structure

One of this study's primary data sources is georeferenced, longitudinal property tax assessment data for Salt Lake County over the period 2008–2018 (Salt Lake County Assessor, 2019). The data are parcel-level and contain inter alia GB status, parcel location, and ownership information. The second source of the data is the annual Cropland Data Layer (CDL) at 30 m resolution for Salt Lake County from 2008 to 2018 (USDA-NASS, 2019). The CDL classifies land cover into multiple types of agricultural and developed land. This study defines farmland as any type of cropland (including idle cropland) and grassland used for grazing. Developed land is classified as open (11%–13%), low (41%–44%), medium (34%), or high-intensity (12%) developed land. The third source of data is the 250 m MODIS-EVI measuring crop productivity (Didan, 2015). EVI has been broadly applied in the literature as an effective predictor of crop productivity (c.f., Arvor et al., 2011; Kouadio et al., 2014), and is preferred over Normalized Difference Vegetation Index since it mitigates satellite measurement errors associated with cloud cover and aerosols. Other ancillary data includes Salt Lake County ZIP Code boundary shapefile (Automated Geographic Reference Center, 2019).

We constructed the data with 1- and 2-year lagged land-use information, as well as land-use change from 1 year to the next. This reduced the sample to 183,940 parcel-year observations from 2010 to 2017. As shown in Table 1, on average, 28.9% of parcels are converted to developed land each year. Approximately, 25.9% of parcels are GB eligible but only 9.5% have GB designation each year (6.4% having less than or equal to five agricultural acres and 3.1% having larger than 5 acres). Parcels are on average 0.283 miles from the urban core, with the farthest being 7.522 miles away from the core. Urban core is defined by medium- and high-intensity developed land. On average, 26.8% of parcels have crop productivity above 50% of the county average, 86.1% of the parcels consist of less than five agricultural acres, and 69.7% of the parcels are primarily in agricultural use.

Furthermore, we find that the distance of non-GB parcels from the urban core has remained relatively stable over time, with a slight decrease from an average of 0.264 miles in 2011 to 0.251 miles in 2017 (Supporting Information: Figure A2). Meanwhile, the mean distance from the urban core boundary of GB parcels increased from 0.459 miles in 2011 to 0.491 miles in 2017. This increase may be attributable to either the withdrawal of GB parcels from the program located closer to the urban core, or to the enrollment of new GB parcels that are located farther from the urban core boundary. Based on our sample data from the years 2008 to 2018, it is evident that a minimum of 54.0% of the GB parcels reaped a net benefit from the GB tax relief. This calculation factors in the

TABLE 1 Summary statistics of the outcome and explanatory variables.

Variable	*N*	Mean	St. Dev	Min	Max
Urban conversion rate (%)	183,940	28.9	40.2	0	100
Greenbelt (GB) (1 if yes)	183,940	0.095	0.293	0	1
Greenbelt having ≥ 5 ag. acres (1 if yes)	183,940	0.064	0.244	0	1
Greenbelt having < 5 ag. acres (1 if yes)	183,940	0.031	0.173	0	1
GB Eligibility (1 if yes)	183,940	0.259	0.438	0	1
Distance from urban core (mile)	183,940	0.283	0.638	0	7.522
Normalized crop productivity (0–1)	183,940	0.268	0.372	0	1
Parcels having ≥ 5 ag. acres (1 if yes)	183,940	0.861	0.345	0	1
Parcels with at least 50% of land used for ag. (1 if yes)	183,940	0.697	0.459	0	1
UFAA (1 if yes)	183,940	0.007	0.081	0	1
UFAA (EVI-based) (1 if yes)	183,940	0.002	0.049	0	1

Note: Urban Farming Assessment Act (UFAA) takes the value of one if the parcels were in food crop production in the last 2 years, year is post-2013, and the food production acreage is larger than two acres but less than five, and 0 otherwise. UFAA (EVI-based) has the same definition as UFAA plus the parcels possess productivity of at least 50% of the average for a given crop, and 0 otherwise.

5-year rollback tax when a parcel no longer maintains its GB status. Only 16.9% of GB parcels retained GB status throughout the entire study period.

Figure 1 provides a snapshot of the study area's GB and non-GB parcels between 2010 and 2018, where we define a parcel as GB if it contains any sub-parcel that has GB status. The figure shows that loss of farmland occurred on GB parcels, especially in the northern and northwestern region of the county. This region is in close proximity to Salt Lake City (indicated by the yellow dot), the capital city of Utah and one of the largest metropolitan areas in the state. Supporting Information: Table B3 provides a more detailed description of GB and non-GB parcles.

3.2 | Empirical strategy

To examine the effect of attaining GB designation, we fit the data to the following equation:

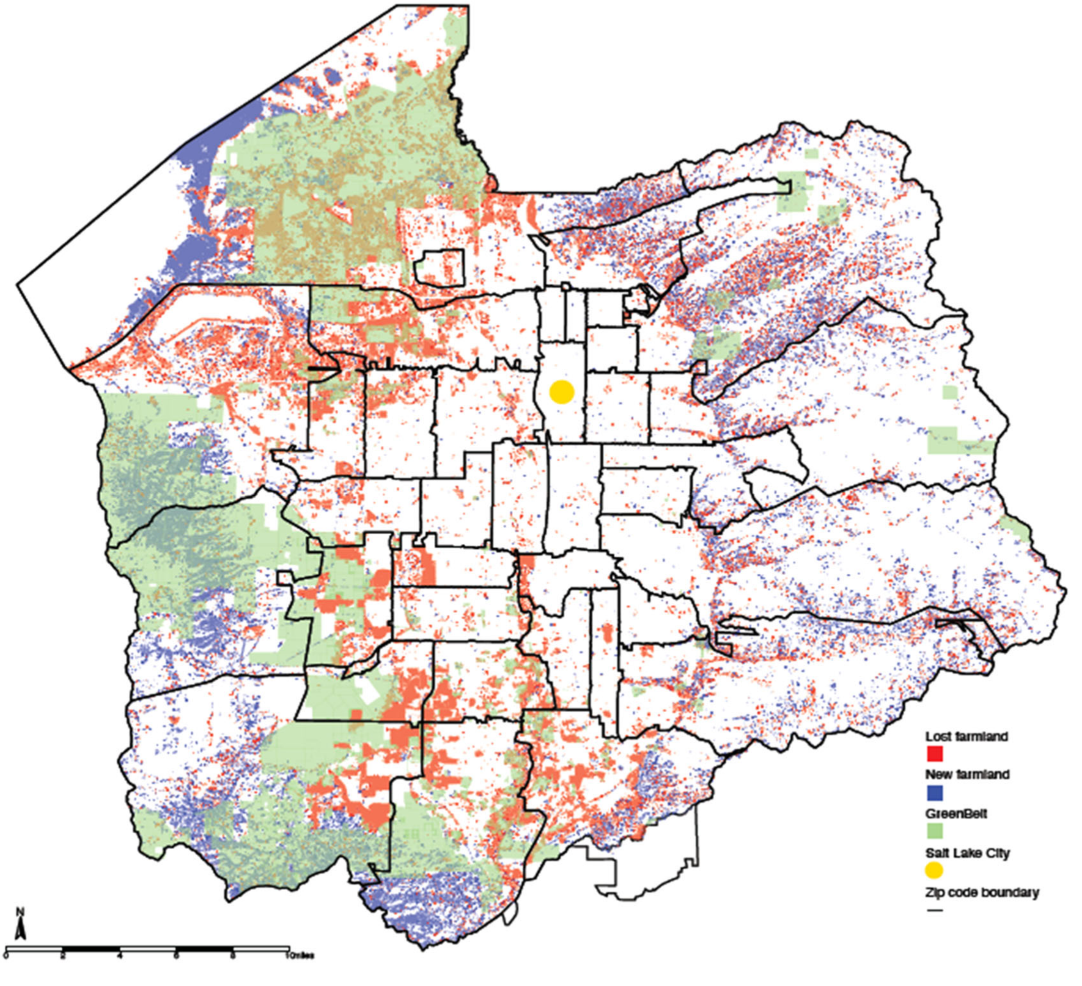

FIGURE 1 Farmland change on Greenbelt (GB) and Non-GB parcels between 2010 and 2018. Land-use change information is derived from Cropland Data Layer (CDL). The GB locations are obtained from the Salt Lake County's assessor office. ZIP Code boundary and Salt Lake City geographical location is obtained from the Utah Automated Geographic Reference Center.

$$\sinh^{-1}Y_{it} = \mathrm{GB}_{it}\beta_1 + \mathrm{EVI}_{it}\beta_2 + \mathrm{D}_{it}\beta_3 + \mathrm{UFAA}_{it}\beta_4 + \mu_i + \lambda_{pt} + \epsilon_{it}, \tag{1}$$

where Y_{it} is the rate of change from farmland to developed land on parcel i between year t and $t+1\,(t = 2010, \ldots, 2017)$; GB_{it} is a dummy variable indicating whether parcel i has received GB designation[2] in year t[3]; EVI_{it}, D_{it}, and $UFAA_{it}$ are three respective time-varying covariates—the parcel's EVI-based agricultural productivity measure, the closest distance of parcel i from the urban core boundary, and a dummy variable proxying for qualification under the Urban Farming Assessment Act (UFAA) which was initiated in 2013 to protect 2–5 contiguous acres of urban farmlands from development. The term μ_i represents the parcel-level fixed effect, λ_{pt} represents the ZIP Code-by-year fixed effect, and ϵ_{it} represents the stochastic error term.

Distance and agricultural productivity are the key variables determining whether an agricultural parcel is ultimately developed in the classical urban growth model. These two variables also affect GB enrollment through the rollback tax and eligibility channels (as indicated in Supporting Information: Table B3, eligible parcels designated as GB are generally located further from the urban core), and thus need to be controlled for. In the absence of information about whether a parcel is assessed under the UFAA, we create a dummy variable indicating whether a parcel met the UFAA qualification in any given year. The dummy variable equals one if (a) year t is greater than or equal to 2013, (b) the parcel is actively devoted to urban farming for at least 2 consecutive years immediately preceding time t, and (c) the parcel size in time t is between two and five contiguous acres. This dummy variable, together with the EVI-based agricultural productivity measure, jointly controls for the effect of the UFAA on farmland conversion.

The term μ_i absorbs all parcel-specific, time-invariant unobserved factors such as topography, soil quality, landowner characteristics, and agricultural zoning[4] that may be correlated with GB designation and farmland conversion. The term λ_{pt} nonparametrically absorbs all time-varying unmeasured factors such as socioeconomic and land-use planning shocks that are common to the GB effects within a given postal zone. To a certain extent, the ZIP Code-by-year indicators capture unobserved neighborhood effects in a postal zone; the idiosyncratic error term ϵ_{it} is clustered at parcel-level and robust to potential heteroskedasticity and serial correlation. To correct for potential skewness in the distribution of Y_{it}, we apply an inverse hyperbolic sine transformation, where the estimated coefficients are interpreted similar to a log-transformed dependent variable. This transformation yields results identical to those using the logarithm for non-zero observations (Gibson et al., 2017; Li, 2019).

3.2.1 | Identification

Of primary interest is the effect of a parcel receiving GB designation. In the process of voluntary GB enrollment, there may exist some unobserved time-varying factors that are not captured by λ_{pt}, but are nevertheless correlated with a landowner's decision process, subsequently affecting the landowner's decisions whether to register her land as GB and whether to convert part of her land to

[2]For each parcel, we calculate the number of agricultural pixels in period t. We then calculate the number of pixels that were in agricultural use in period t but in urban use in period $t+1$. Y_{it} is the ratio of these two numbers.

[3]One may expect that GB designation in earlier years also affects the opportunity cost of farmland development during period t to $t+1$ if a parcel received GB designation in any particular year between $t-4$ and $t-1$, but had not been levied the rollback tax until the parcel was converted to urban use in year t. To address this concern, we conducted a robustness check by redefining GB_{it} as a dummy variable indicating whether parcel i had been designated as GB in any year between $t-4$ and t. As shown in Supporting Information: Table B16, redefining GB_{it} in this manner does not undermine our basic results.

[4]Rezoning is not a concern because it mostly occurs with agricultural parcels smaller than two acres in our study area. (see Supporting Information: Table B17 for the related robustness checks).

urban use. To address this potential endogeneity of GB designation, we estimate a two-stage least squares (2SLS) regression where the first-stage equation is specified as:

$$GB_{it} = Z_{it}\Gamma + EVI_{it}\beta_2 + D_{it}\beta_3 + UFAA_{it}\beta_4 + \mu_i + \lambda_{pt} + \epsilon_{it}, \tag{2}$$

where Z_{it} represents the instrument (dummy) variable for GB designation, indicating whether parcel i satisfies both the land-size and land-use criteria (henceforth GB Eligibility). Note that small parcels can also meet the land-size criterion if the total agricultural area under the same ownership exceeds five acres. The terms EVI_{it}, D_{it}, $UFAA_{it}$, μ_i, λ_{pt}, and ϵ_{it} are defined similarly to that in Equation (1). Equation (2) is estimated as a linear probability model, which has been broadly adopted in the literature (Alix-Garcia et al., 2013).

Below, we discuss the validity of the Z_{it} instrument based upon two fundamental assumptions—monotonicity and the exclusion restriction—proposed by Angrist et al. (1996). Monotonicity implies that (the probability of) receiving GB designation is a nondecreasing function of GB Eligibility. Since GB Eligibility indicates whether the GB designation criteria has been satisfied, land parcels satisfying the criteria are, all else equal, more likely to obtain GB designation. Consequently, our instrument is likely to meet the monotonicity assumption. The exclusion restriction requires that the effect of GB Eligibility on farmland conversion occurs strictly via the effect of GB Eligibility on GB designation. Since the exclusion restriction is not directly verifiable from the data, we assess possible violations of this assumption by investigating the key non-GB channel—the effect of GB Eligibility on reservation rent, where reservation rent is composed primarily of rent associated with agricultural use and the opportunity cost of conversion capital. In Supporting Information: Appendix E, we exclude the possibility that the land-use or land-size criteria affect farmland development through affecting reservation rents, and the possibility that developers only target land that qualifies for GB designation. Although we cannot rule out all potential threats to identification, the panel structure of the data allows us to block many non-GB channels between GB Eligibility and farmland conversion. Therefore, GB Eligibility is likely to be a valid instrument.

3.2.2 | The role of allowing nonagriculture on a GB parcel

To explore whether landowners intentionally exploit the GB Act by conducting nonagricultural activities on a GB parcel, we augment the specification in Equation (1) to allow for the GB effect to vary based on farmland acreage. Specifically, we classify GB parcels into two groups: a group including parcels comprised of no more than five acres of farmland, denoted as GB^s, and a group consisting of parcels comprised of greater than five acres of farmland, denoted as GB^l. This classification creates two binary variables equaling one if a parcel falls into the GB^s or GB^l group, respectively, and zero otherwise. These two dummy variables then replace GB in Equation (1).

$$\sinh^{-1}Y_{it} = GB^s_{it}\beta^s_1 + GB^l_{it}\beta^l_1 + EVI_{it}\beta_2 + D_{it}\beta_3 + UFAA_{it}\beta_4 + \mu_i + \lambda_{pt} + \epsilon_{it}, \tag{3}$$

and the associated first-stage equations for GB^s and GB^l are

$$GB^j_{it} = Z_{it}\Gamma + I_{it}\tau + EVI_{it}\beta_2 + D_{it}\beta_3 + UFAA_{it}\beta_4 + \mu_i + \lambda_{pt} + \epsilon_{it}, j = s, l, \tag{4}$$

where Z_{it} is defined as in Equation (2), and I_{it} is an additional dummy variable indicating whether the agricultural area of parcel i is no more than five acres in year t, 0 otherwise. Variable I_{it} serves as an extra IV instrument for GB^s and GB^l, respectively, and therefore similar rationale applies regarding the exclusion restriction.

The heterogeneity analysis in Equations (3) and (4) allows us to examine a possible adverse effect of the GB policy on farmland protection. A statistically significant, positive coefficient estimate for

GB^l would support the hypothesis that landowners intentionally take advantage of tax relief and convert at least part of their GB parcel(s) to urban use. The analysis also enables us to probe a scenario in which this policy loophole is fixed. The logic is, when a GB-designated parcel consists of no-more-than-five-acre of farmland, a rational landowner will not convert any farmland to urban use to continue receiving tax relief associated with the parcel. One would then expect a nonpositive or insignificant point estimate for GB^s. Otherwise, the parcel becomes ineligible for GB designation and the landowner will face the rollback tax penalty. The no-more-than-five-acre of farmland restriction is presumed to act as a constraint on a landowner's land-use decision-making process in the GB^s group, which creates a counterfactual, where the GB policy prohibits owners of GB parcels from converting any farmland to urban use or selling their land to developers. Admittedly, prohibiting GB parcel conversion may also discourage landowners from enrolling into GB to begin with. In the end, completely nailing down landowners' decisions on GB designation is beyond the scope of this study.

4 | RESULTS

4.1 | Does Utah's GB act preserve farmland from development?

Table 2 presents the estimated overall GB effect using data from all agricultural parcels in Salt Lake County during 2010–2017. Columns 1a and 1b report results from the 2SLS estimation of Equations (1) and (2). Column 2 reports the results of an ordinary least squares (OLS) estimation of Equation (1) alone. Results with less-conservative model specifications are presented in Supporting Information: Table B3.

The probability of receiving GB designation increases with GB Eligibility at the 1% significance level (col. 1a). This result supports the monotonicity assumption of a valid IV. The GB Eligibility instrument demonstrates strong explanatory power, with an F-test statistics of 62,588, well above 10, the level signifying a weak instrument (Staiger & Stock, 1997; Stock et al., 2002). This strong IV-GB correlation greatly reduces any potential bias, even if the exclusion restriction assumption is violated (Angrist et al., 1996). The Wu-Hausman test rejects the null hypothesis of the GB designation dummy variable being exogeneous with respect to the rate of farmland conversion (at the 10% significance level), suggesting that the 2SLS regression is the preferred specification. As anticipated, parcels with higher EVI-based agricultural productivity are more likely to receive GB designation. Moreover, parcels located closer to urban core boundaries are less likely to be designated GB, which reinforces our hypothesis concerning the role of the rollback tax in affecting the landowner's GB designation decision.

Turning to the second-stage regression results, obtaining GB designation reduces the rate of farmland conversion by approximately 1.3% per annum (col. 1b). This result suggests that the GB Act has indeed helped protect farmland from urban development in Salt Lake County. The rate of farmland conversion also decreases with distance from an urban core boundary. This finding is consistent with the monocentric city model, that is, the farther a parcel is located from the city center, the lower its bid rent. Smaller bid rents in turn reduce the likelihood of conversion to urban use. In contrast, the rate of farmland conversion increases with EVI-based agricultural productivity. We attribute this seemingly counterintuitive result to the fact that modern communities tend to settle on fertile land. Consequently, urban centers emerge there (Brinkley, 2012; Bryce, 2016). Similar findings have been reported by Seto and Kaufmann (2003) and Li et al. (2013).

There may be concerns that "developed, open space" is incorrectly classified as urban use (Lark et al., 2021). In the context of this study, most "developed, open space" areas are likely to be developed, although the overall negative effect of GB designation on farmland conversion is mainly driven by protecting farmland from converting to "developed, open space," rather than to "developed, high/medium/low intensity" (Supporting Information: Table B5). The reason is twofold.

TABLE 2 Estimated effects of Greenbelt (GB) designation on farmland conversions.

	Dependent variable		
	GB	% Ag to D	% Ag to D
	First stage	Second stage	OLS
	(1a)	(1b)	(2)
GB		−0.013**	−0.001
		(0.004)	(0.003)
		[0.005]	[0.004]
GB eligibility	0.634***		
	(0.009)		
	[0.003]		
Distance (mile)	0.007***	−0.033***	−0.033***
	(0.002)	(0.002)	(0.002)
	[0.002]	[0.003]	[0.003]
Productivity	0.010***	0.060***	−0.059***
	(0.002)	(0.003)	(0.003)
	[0.002]	[0.003]	[0.003]
UFAA	−0.012	−0.030***	−0.029***
	(0.010)	(0.008)	(0.008)
	[0.006]	[0.010]	[0.010]
Parcel FE	Yes	Yes	Yes
Year x ZIP FE	Yes	Yes	Yes
Weak inst. (*F*-stat)	62588	-	-
Weak inst. (*p*-val)	<2.2e-16***	-	-
Wu-Hausman (*p*-val)	0.06048*	-	-
Observations	183,940	183,940	183,940
R^2	0.340	0.005	0.005
F-test (*p*-val)	<2.2e-16***	<2.2e-16***	<2.2e-16***
F-test (*F*-state)	8.4989	950.078	6.7779
Mean of dep. variable	0.095	0.289	0.289

Note: The dependent variable is the inverse hyperbolic sine transformed rate of farmland conversion for the second stage and OLS models. This measures the rate of conversion to all kinds of developed land (open, low, medium, and high intensity). The dependent variable for the first-stage regressions is GB designation. Specifications in all columns include parcel and ZIP Code-by-year fixed effects. Standard errors in parenthesis are clustered at the parcel level and robust to both heteroskedasticity and serial correlation. Standard errors in brackets are clustered at the zipcode level.

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

First, only 5% of the "developed, open space" land pixels in our data set are designated GB. This is in stark contrast to agricultural land pixels, of which 30% are designated GB. Thus, there appears to be a systematic difference between agricultural land and "developed, open space." Second, although "developed, open space" may not fully meet the criteria of urban use, these land parcels are likely to be converted to urban use in the near future. If a parcel is purchased by a developer, the developer needs time to develop the land. The parcel may look like fallow ground and be identified officially as "developed, open space." But it will be eventually become urban use.

4.2 | Is allowing nonagricultural activities on a GB parcel a cause for concern?

To examine whether landowners exploit preferential GB tax assessment through fostering nonagricultural activities on GB parcels, we conduct an analysis depicted by Equations (3) and (4), which distinguishes GB parcels comprised of more than five acres from GB parcels comprised of less than or equal to five acres.[5] The results are reported in Table 3, where columns 1a and 1b, respectively, correspond to the two first-stage regressions for GB^s and GB^l, and column 1c presents the estimates obtained from the second-stage regression.

Consistent with the IV validity test reported in Table 2, the *F*-tests for the significance of the two instruments are strongly correlated with GB^s and GB^l, respectively, and the Wu-Hausman tests reject the null hypothesis of exogeneity for both GB variables. Coefficients estimates for all variables in the first-stage regressions are consistent with our expectations, except the statistically insignificant estimate of GB Eligibility in column 1b, possibly because of the collinearity between GB Eligibility and the agricultural area dummy.

In the second-stage regression (col. 1c), the coefficient estimate for GB^s is nearly identical to the overall GB estimate reported in column 1b of Table 2, whereas the coefficient estimate for GB^l is large, positive, and highly statistically significant. The tax reduction incentive associated with GB designation tends to encourage owners of GB parcels exceeding five acres to develop farmland at an annual rate of 24.2%. This rate is of much higher magnitude than the negative effect (−1.3%) of GB^s on farmland conversion. This result affirms the possibility of exploiting GB tax relief on larger parcels when landowners are permitted to convert portions of their GB parcels to nonagricultural use. The finding is supported by the data per se: out of 5679 (parcel-year) GB^l observations, urban development occurred on 1281 parcels, with more than 83% of these parcels remaining in GB designation after land-use conversion. The total developed area on GB^l parcels is nontrivial; it accounts for 67% of the total area (3272 acres) converted from agriculture to urban use on all GB parcels over the study period. In contrast, owners of smaller GB parcels are unable to exploit this tax-relief contingency.

We conduct an additional heterogeneity analysis by distinguishing GB parcels with primary agricultural use from those with primary nonagricultural use (col. 2a–2c, Table 3). As anticipated, farmland conversion is more likely to occur on GB parcels with primary agricultural use than on those with primary nonagricultural use. It can be plausibly argued that an owner of a GB parcel with a higher percentage of farmland is more likely to exploit the law by either converting a portion of her land to urban use or selling some of her property to land developers.

The average effect of GB designation might hide important information about the effect on farmland conversion of parcels within the neighborhood of the five-acre restriction. To examine this concern, we restrict the analysis to six alternative samples centered at 5 and 5.5 acres of agricultural use, with three alternative lower bounds (0, 2.5, and 3 acres), respectively. The estimated local effects are reported in Table 4. As shown in column 1, roughly 91% of the observations fall within the range of 0–10 acres, implying a moderate number of extreme values for agricultural acreage in the sample. Thus, this reduced sample yields the similar results as those based on the whole sample (i.e., the global estimates) reported in Tables 2 and 3. Although restricting the analysis to agricultural

[5]Recall that the five-acre limit is one of the land-use criteria for GB designation. Parcels that are less than five acres are eligible for GB designation in conjunction with other eligible land under the same ownership.

TABLE 3 Heterogeneity in Greenbelt (GB) effects on farmland conversion.

	Dependent variable					
	GB^s First stage (1a)	GB^l First stage (1b)	% Ag to D Second stage (1c)	GB (PriAg) First stage (2a)	GB (NPriAg) First stage (2b)	% Ag to D Second stage (2c)
GB^s			−0.013** (0.006) [0.007]			
GB^l			−0.242*** (0.031) [0.035]			
GB (PriAg)						0.464*** (0.026) [0.012]
GB (NPriAg)						−1.399*** (0.059) [0.027]
GB eligibility	0.635*** (0.009) [0.001]	−0.002 (0.007) [0.001]		0.471*** (0.010) [0.002]	0.163*** (0.006) [0.001]	
≤5 Ag Acre	0.163*** (0.010) [0.004]	−0.167*** (0.005) [0.003]				
PriAg				0.098*** (0.003) [0.002]	−0.097*** (0.003) [0.002]	
Distance (mile)	0.004*** (0.002) [0.001]	−0.002*** (0.001) [0.001]	−0.033*** (0.002) [0.003]	0.008*** (0.002) [0.002]	−0.001 (0.001) [0.001]	0.040*** (0.003) [0.004]
Productivity	0.005*** (0.001) [0.001]	0.030*** (0.001) [0.001]	−0.057*** (0.003) [0.003]	0.013*** (0.002) [0.002]	−0.004*** (0.001) [0.001]	−0.002 (0.004) [0.004]
UFAA	−0.010 (0.009) [0.005]	−0.015 (0.007) [0.004]	−0.023*** (0.008) [0.010]	−0.003 (0.010) [0.006]	−0.009 (0.006) [0.005]	−0.034 (0.016) [0.013]
Parcel FE	Yes	Yes	Yes	Yes	Yes	Yes

(Continues)

TABLE 3 (Continued)

	Dependent variable					
	GB^s First stage (1a)	*GB*^{l} First stage (1b)	% Ag to D Second stage (1c)	GB (PriAg) First stage (2a)	GB (NPriAg) First stage (2b)	% Ag to D Second stage (2c)
Year × ZIP FE	Yes	Yes	Yes	Yes	Yes	Yes
Weak inst. (*F*-stat)	52230	2281	-	−423.67	6660.1	-
Weak inst. (*p*-val)	<2.2e-16***	<2.2e-16***	-	<2.2e-16***	<2.2e-16***	-
Wu-Hausman (*p*-val)	0.01871**	3.827e-15***	-	<2.2e-16***	<2.2e-16***	-
Observations	183,940	183,940	183,940	183,940	183,940	183,940
R^2	0.462	0.057	0.001	0.221	0.103	0.001
Mean of dep. variable	0.064	0.031	0.289	0.064	0.031	0.289

Note: The dependent variable for the first stage (column 1a) is GB parcels with agricultural acreage of no more than five acres, whereas the dependent variable for the first stage regression (column 1b) is GB parcels with agricultural acreage of no less than five acres. The dependent variable for the first stage (column 2a) is GB parcels that are primarily in agricultural use, whereas the dependent variable for the first stage (column 2b) is GB parcels that are primarily in nonagricultural use. The dependent variable is the inverse hyperbolic sine transformed rate of urban conversion measured in acres in the second-stage model presented in columns 1c and 2c. This measures conversion to all proportions of developed land (open, low, medium, and high density). All specifications include parcel and ZIP Code- by-year fixed effects. Standard errors in parenthesis are clustered at the parcel level and robust to both heteroskedasticity and serial correlation. Standard errors in brackets are clustered at the zipcode-level.

$^{**}p < 0.05$; $^{***}p < 0.01$.

acreages of 2.5–7.5 acres reduces the sample size to 8% of the total sample (col. 3), the overall and heterogeneous effects are qualitatively similar to the global estimates. This finding holds until the lower bound of agricultural acreage increases to ~3 acres, where the estimated negative overall effect and the estimated positive effect for the GB^l group alone remain, but the estimated negative effect for GB^s becomes statistically insignificant (col. 5). The above findings are robust to a slight relaxation of the five-acre restriction to 5.5 acres, except for the sample with a lower bound of agricultural acreage of 2.5 acres, where the estimated effect of GB^s is negative but statistically insignificant. This may be because the negative effect on GB parcels comprised of 2.5–5 acres of farmland is partially offset by the positive effect on GB parcels comprised of 5–5.5 acres. It also leads to a statistically insignificant coefficient estimate for the overall GB effect.

In addition to the identification efforts discussed above, we probed the robustness of the estimated GB effects in several other ways. We found little evidence that undermines our basic conclusions. Interested readers can find more discussion about the robustness checks in Supporting Information: Appendix F and the structural analysis of the GB effect in Supporting Information: Appendix G.

4.3 | The magnitude of the GB effect

Supporting Information: Table B19 develops the measure of the magnitude of the GB effects over the entire study period, 2010–2018 by combining the point estimates and the sample means (see table note for details). As shown in column 2, the GB Act protects GB^s parcels from urban development at a normalized rate of merely 0.28% of the total farmland conversion. This policy effect on GB^s is, however, completely offset by the adverse effect of GB designation via the encouragement of GB^l landowners to convert portions of their land to urban use. This adverse effect accounts for 2.59% of total farmland conversion. In comparison, transitional shocks common to the

TABLE 4 Local two-stage least squares (2SLS) estimates of Greenbelt (GB) effects on farmland conversion.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample range (ag. acres)	**0–10**	**0–11**	**2.5–7.5**	**2.5–8.5**	**3–7**	**3–8**
Sample centered at (ag. acres)	**5**	**5.5**	**5**	**5.5**	**5**	**5.5**
	Panel A: Overall effect					
GB	−0.015**	−0.014***	−0.008**	−0.010	−0.010*	−0.011*
	(0.006)	(0.005)	(0.004)	(0.006)	(0.006)	(0.006)
	Panel B: Heterogeneous effect					
GB^s	−0.015**	−0.014***	−0.006*	−0.006*	0.006*	−0.008
	(0.006)	(0.005)	(0.004)	(0.004)	(0.006)	(0.006)
GB^l	0.195***	0.210***	0.130***	0.130***	0.142***	0.123***
	(0.029)	(0.020)	(0.021)	(0.021)	(0.029)	(0.020)
Parcel FE	Yes	Yes	Yes	Yes	Yes	Yes
Year × Zip FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	166,477	167,449	15,433	16,152	11,932	13,339

Note: The dependent variable is the inverse hyperbolic sine transformed rate of urban conversion measured in acres in the second-stage model. This measures conversion to all proportions of developed land (open, low, medium, and high density). All specifications include parcel and ZIP code-by-year fixed effects. Standard errors in parenthesis are clustered at the parcel level and robust to both heteroskedasticity and serial correlation. Standard errors in brackets are clustered at the zipcode level.

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

conversion of farmland within the same postal zone are the major factor slowing down farmland development. Without these shocks, the annual rate of farmland conversion would have been 40.95% higher than the actual conversion rate. Yet, the unobserved time-invariant parcel fixed effects are the dominant contributor to farmland development, accounting for 1.366 times the actual conversion rate.

In concert with the overall decline in the farmland conversion rate is the decreasing normalized residual effect, which is composed of parcel and ZIP Code-by-year fixed effects, to capture the socioeconomic and political-policy unobservables (see Supporting Information: Figure A3). An examination of the evolution of farmland development across the state's counties suggests a trend of urban sprawl in other more densely populated counties, such as Utah and Davis, adjacent to Salt Lake County over the period 2011–2016 (Yang et al., 2018). This helps release the pressure of urban development in Salt Lake County. These results are in line with the findings of Alterman (1997), Jacobs (1999), and Li (2019).

5 | CONCLUSIONS

This paper used an IV-fixed effects approach to investigate the effectiveness of Utah's GB Act in preserving peri-urban farmland in Salt Lake County from 2010 to 2018. We find that the annual conversion rate of GB designated farmland to urban development is approximately 1.3% lower than the conversion rate of non-GB parcels, driven primarily by the protection of GB parcels with less than five acres of agricultural area. This effect translates into only 68 acres of farmland being preserved per year. In contrast, the GB tax break tends to incentivize partial urban development on GB parcels with greater than five acres devoted to agricultural production. The average annual conversion rate on these larger GB parcels is roughly 24% higher than that of non-GB parcels, which translates into roughly 14,450 acres of farmland being converted per year in Salt Lake County during the study period. This adverse effect dwarfs the positive GB effect on farmland preservation. A structural break analysis (Supporting Information: Appendix H) indicates that the adverse GB effect coincides with Salt Lake County's economic growth over time.

This study contributes to the ongoing debate concerning taxation-based farmland protection, including programs like the UFAA, which was recently amended to lower the minimum requirement for parcel size (Urban Farming Assessment Act Amendments, 2019). The paper's findings support growing concerns about a policy loophole that permits agriculture to be a secondary use of a GB parcel. Tax policy shifts the tax burden of different taxpayers to a certain extent. Other taxpayers may end up either paying higher taxes to protect farmland—a widely criticized distributional effect that should be considered in public policy decisions—or receiving fewer public services, such as cuts in the funding of highways (Bigelow & Kuethe, 2023).

How to encourage participation of landowners in the GB program merits further exploration. In our sample, there are over 47,500 parcel-year observations qualified for GB designation during the study period, yet only 37% of those parcels actually enrolled into the GB program. Whether deciding to amend the current program or designing a new one, policymakers must balance the tradeoff between encouraging GB participation among landowners and at the same time preventing them from abusing the tax-break provision. Finally, our evidence-based findings suggest that the GB act has offered more incentives for development than protection. For the farmland protection programs in other states allowing secondary use of agricultural land, it appears that reevaluation of these programs is needed.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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