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The effect of place on voting behavior: The case of the Arizona proposition to legalize recreational marijuana

Mason Clay Mathews[1] | **A. Stewart Fotheringham**[2]

[1]Knowledge Exchange for Resilience, School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, Arizona, USA

[2]Spatial Analysis Research Center (SPARC), School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, Arizona, USA

Correspondence
Mason Clay Mathews, Knowledge Exchange for Resilience, School of Geographical Sciences and Urban Planning, Arizona State University, Coor Hall, PO Box 875302, Tempe, AZ 85287-5302, USA.
Email: mason.mathews@gmail.com

Abstract

In 2020, Arizonans approved Proposition 207, the Smart and Safe Arizona Act, which legalized recreational marijuana sales. Previous research has typically used non-spatial survey data to understand marijuana legalization voting patterns. However, voting behavior can, in part, be shaped by geographic context, or place, which is unaccounted for in aspatial survey data. We use multiscale geographically weighted regression to analyze how place shaped Proposition 207 voting behavior, independently of demographic variations across space. We find significant spatial variability in the sensitivity of voting for Proposition 207 to changes in several of the predictor variables of opposition and support for recreational marijuana legalization. We argue that local statistical modeling approaches provide a more in-depth understanding of ballot measure voting behavior than the current use of global models.

KEYWORDS

Arizona, ballot measure, cannabis, direct democracy, local context, multiscale geographically weighted regression, place, Proposition 207, recreational marijuana legalization, space, United States, voting behavior

Related Articles

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A commonly used phrase in American politics is that "all politics is [*sic*] local" (Matthews, 1999, p. 48). Associated with Tip O'Neill, the former Speaker of the U.S. House of Representatives, this phrase encapsulates that the voting behavior of politicians in Washington can be explained by what their voters at home care about (Matthews, 1999). Direct democracy in the form of ballot measure initiatives is the epitome of the "all politics is [sic] local" axiom because the electorate makes decisions on policy initiatives without elected representatives as intermediaries (Matsusaka, 2005a). Ballot measures enable eligible citizens to vote *yes* or *no* on specific propositions on an election ballot. Since voting occurs at the level of the individual voter, it is inherently a *local* democratic process, in which people directly decide on legislation that can profoundly affect their lives. Consequently, local variations in ballot measure voting behavior are important to study for several reasons.

First, state-wide ballot measures must be implemented *locally*. Direct democracy initiatives are not always implemented as they appear on a ballot and do not always shape policy as anticipated (Gerber et al., 2001). While ballot measures often lay out broad policy changes, legislatures and local governments are often tasked with the fine details of implementation, enforcement, and administration (Matsusaka, 2005b). In some instances, local governments are given the opportunity to enact local laws and ordinances that may counter the stated goals of the ballot measure. Statewide ballot initiatives typically promise statewide policy changes. However, because implementation occurs at the local level, the realization of statewide objectives is often dependent on local preferences. A better understanding of how local context shapes voting preferences can help us understand why some local governments subsequently enact local laws and ordinances that may contradict components promised as part of a statewide ballot measure.

Second, the impacts of state-wide ballot measures often vary *locally*. Whether due to local implementation strategies, or other factors, the costs and benefits of such measures are often distributed unevenly. For example, if the positive economic benefits of a ballot measure accrue only to a few urban areas, while rural areas bear the negative costs, rural–urban tensions can grow (Smith, 2007). Equally, if state-wide ballot measures benefit only certain ethnic groups or economic classes, existing equity issues can be exacerbated (Lewis, 2012). The capacity to identify local variations in ballot measure voting can help us understand subsequent patterns in the distribution of the costs and benefits of ballot measure implementation.

Third, states, organizations, and individuals can use the results of analyses of *local* geographic variations in existing ballot measure voting data to design *future* ballot measure initiatives. A compilation of ballot measure studies using local statistical models that indicate which sociodemographic variables predict voting behaviors and how they vary spatially could be used to tailor future ballot measures to geographically meet the needs of citizens.

Consequently, it is important for analyses of voting behavior to capture *local* effects and to allow for possibly locally varying voting behavior. Unfortunately, most voting behavior analyses use global statistical models (commonly ordinary least squares [OLS] regression) that may overlook locally varying effects. One model that can capture local geographical contextual effects is multiscale geographically weighted regression (MGWR; Fotheringham et al., 2017). MGWR is a local modeling approach that makes it possible

to understand different facets of spatial relationships, particularly whether the processes (conditioned associations) being modeled vary over space. This is especially useful in identifying the effect of "place" or local context on behavior, which can be achieved by estimating local slope and intercept parameters conditioned on a set of variables describing the sociodemographic composition of the population in each locale (Fotheringham et al., 2021; Li & Fotheringham, 2021).

While variations in sociodemographic variables help us understand variations in ballot measure voting behavior, the effect of such variables may not be geographically uniform. Local context shapes voting behavior, making blanket assumptions about relationships between sociodemographic effects and voting behavior problematic. A demographic variable that is a good predictor of voting behavior in one place may be a poor predictor in another. Fotheringham and others (2023) describe such contextual effects as "behavioral." Equally, ballot measure voting behavior may be a function of local conditions that have not been captured in the model, either because they have not been considered or they are impossible to measure. Voting behavior may vary based on *local* conditions unrelated to the demographic characteristics of residents. Fotheringham and others (2023) describe such contextual effects as "intrinsic." The inability of traditional global models to capture either intrinsic or behavioral contextual effects can lead to omitted variable bias and misleading inferences being drawn from models of voting behavior. Frameworks that capture localized voting effects, such as MGWR, are therefore important not only to identify and quantify geographical contextual effects on voter behavior but also because they relieve the misspecification bias in parameter estimates derived from models that do not incorporate the effects of geographical context.

Over the past 30 years, few ballot measures in the United States have been as controversial, or as widespread, as those associated with legalizing medical and recreational marijuana. The legalization of recreational marijuana is one of the largest direct democracy experiments currently taking place in the United States. Voters in states nationwide are making decisions regarding the legalized sale of marijuana that have local, regional, and national implications. Not only do these ballot measures create a clash between federal and state drug enforcement policies, as well as between factions of society, but they also have the potential to shape public health, economic, and other social outcomes in the states that vote to adopt them. The widespread nature of marijuana legalization ballot measures makes them an interesting test case to illustrate the importance of understanding how local context shapes voting behavior. One such example, Proposition 207, the Smart and Safe Arizona Act, provides an opportunity to show how MGWR can be used to understand local variations in ballot measure voting. In this analysis, we address the following research questions:

(i) What are the factors that associate significantly with voting for or against Proposition 207 and how similar are these to those identified in similar voting behavior in other states?
(ii) Does modeling voting behavior locally through MGWR, and hence capturing local contextual effects, offer significant advantages over a traditional global model approach?
(iii) How important is the geographical contextual or place effect on voting compared to the influence of traditional sociodemographic factors? Does "place" really matter when it comes to voting on marijuana legislation?

By focusing on local voting behavior determinants, we believe this study's findings can help government, nonprofit, and for-profit organizations tasked with implementing Proposition 207 better understand the drivers of support for, or opposition to, marijuana legalization. This research should also serve as a blueprint for using local models such as MGWR to understand how context shapes voting behaviors for other types of ballot measures because, although the focus of this article is marijuana legalization, the broad issues that are addressed here are important for the analysis of any type of voting behavior at all spatial scales.

A brief history of marijuana legalization in the United States

Hemp was once a cash crop in the United States. Although the 1937 Marihuana Tax Act was designed to prohibit recreational marijuana use, in practice the entire marijuana plant became illegal at the federal level due to the way the law was interpreted and enforced (Galliher & Walker, 1977; Musto, 1972). Marijuana criminalization intensified in 1970 with the Controlled Substances Act, which classified marijuana as a Schedule I drug with no accepted medical use and a high potential for abuse (Hodroff, 2014). In the 1990s, marijuana enforcement became a key element of the War on Drugs (King & Mauer, 2006), a policy followed over decades that has been highly criticized as being ineffective and racially biased (Bender, 2013; Jensen et al., 2004; Moore & Elkavich, 2008; Schoenfeld, 2012; Tonry, 1994).

Over the last 50 years at the state level, the legal pendulum has swung in the other direction, with extensive efforts to legalize medical and recreational marijuana. In the 1970s, several states enacted laws to decriminalize marijuana by lowering penalties and fines (MacCoun et al., 2009; Roffman, 1977). However, state decriminalization did not affect federal laws or War on Drugs policies; arrests and incarceration continued in the states that decriminalized marijuana (MacCoun et al., 2009). The push to legalize medical marijuana began to gain traction in 1996, when California became the first state to do so with the passage of Proposition 215, the Compassionate Use Act of 1996 (Abrams, 1998). In subsequent years, other states followed, and by April 2023, 38 states, Washington, D.C., and several U.S. territories had legalized different forms of medical marijuana.[1] The efforts to legalize medical marijuana laid the groundwork for efforts to legalize recreational marijuana (Kilmer & MacCoun, 2017).

Recreational marijuana legalization efforts began to bear fruit in 2012, when Colorado and Washington passed Amendment 64 (CO) and Initiative 502 (WA; Payán et al., 2021). Proponents of recreational marijuana argued that legalization would generate economic revenues, fill tax coffers, and create jobs (Doussard, 2019; Swinburne & Hoke, 2020). Once medical and recreational marijuana legalization occurred, billions of dollars of revenue awaited companies and individuals licensed to sell it (Uzialko, 2022). Proponents of marijuana legalization also argued that it would alleviate pressure on the penal system and end some of the injustices and inequities of the War on Drugs (Miron & Partin, 2021).

Opponents raised questions regarding the possibility of recreational marijuana exacerbating existing mental health issues (Zvonarev et al., 2019). They also claimed that marijuana is often ingested through smoking, which can cause lung damage similar to smoking tobacco (Tetrault et al., 2007). Opponents also raised concerns regarding marijuana use, impaired driving, and traffic fatalities (Asbridge et al., 2012). The potential for increases in crime associated with marijuana legalization has also been raised (Wu et al., 2021), as have impacts on youth development and education (Hammond et al., 2020).

As of November 2023, the financial and social arguments supporting recreational marijuana legalization appeared to outweigh arguments opposing it for many voters; 24 states and Washington, D.C. had passed recreational marijuana legislation.[2] In 13 states and Washington, D.C., recreational marijuana was legalized via ballot initiatives.[3] In two states, legislatures referred ballot measures for voter approval. In nine states, legalization occurred via legislative bills (see Figure 1).[4] According to U.S. Census population estimates, following the passage of the November 7, 2023, Ohio Issue 2 ballot measure, 52.56% of the country's population lived in

[1]Although they had not legalized medical marijuana, by September 19, 2022 Georgia, Indiana, Iowa, Tennessee, Texas, and Wisconsin had legalized the use of CBD oils. Some states, such as Texas, have also legalized low-THC oils. Kentucky has recently passed medical marijuana legislation (SB47). https://www.ncsl.org/health/state-medical-cannabis-laws (accessed October 25, 2023).

[2]https://ballotpedia.org/Marijuana_laws_and_ballot_measures_in_the_United_States (accessed November 13, 2023).

[3]https://ballotpedia.org/Marijuana_laws_and_ballot_measures_in_the_United_States (accessed November 13, 2023).

[4]https://ballotpedia.org/Marijuana_laws_and_ballot_measures_in_the_United_States (accessed November 13, 2023).

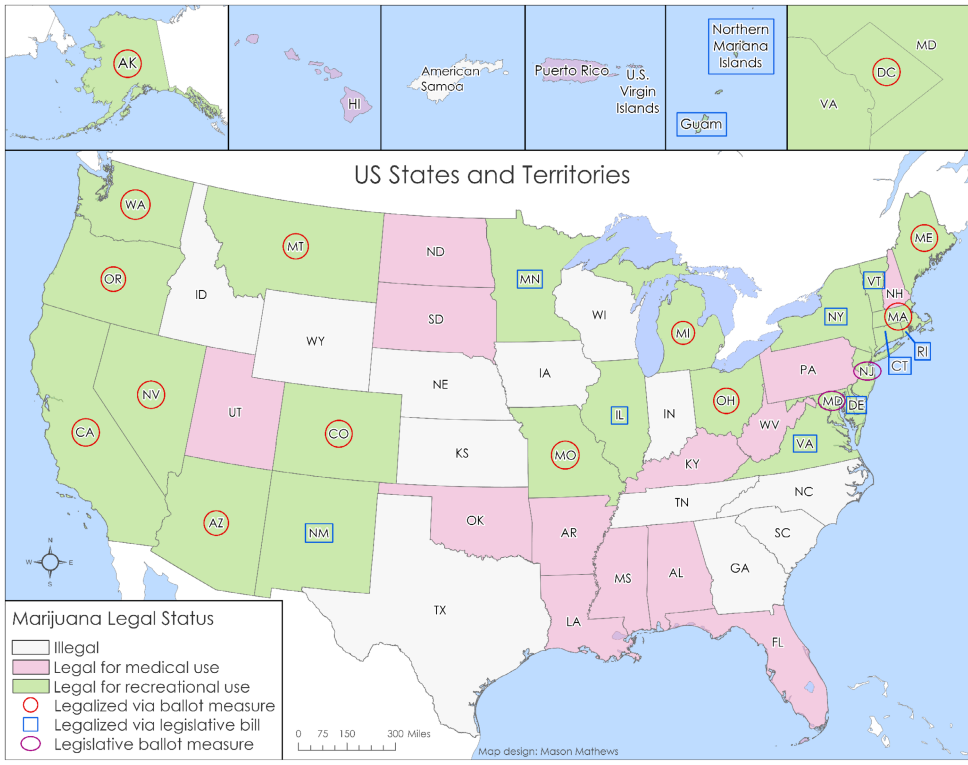

FIGURE 1 Legal status of medical and recreational marijuana in the United States and territories.

a state where marijuana was legal.[5] States with higher levels of direct democracy—where voters can use initiatives and referendums to initiate policy change, and where state legislatures have limited capacity to alter voter initiatives—demonstrated higher probabilities of legalizing recreational marijuana (Vann, 2022).

A brief history of marijuana legalization in Arizona

The effort to legalize marijuana in Arizona dates back several decades. Early proponents argued that medical marijuana was necessary for pain management and therapeutic and palliative care for people suffering from debilitating and/or terminal illnesses such as glaucoma, cancer, and amyotrophic lateral sclerosis (Aurit, 2012; Orenstein, 2015). Arizona's path to legalizing medical marijuana began with Proposition 200, The Drug Medicalization, Prevention, and Control Act of 1996, which allowed licensed physicians to prescribe cannabis (Bassett, 1998). Proposition 200 was approved by 65% of Arizona voters. However, it was repealed by state legislators four months later, partly because physicians risked losing their licenses due to the clash between existing federal drug laws and the new Arizona law (Bassett, 1998; Pacula et al., 2014). Proposition 300, a 1998 veto referendum, reinstated the law, but failed to legalize medical marijuana due to language conflicting with federal law (*State-By-State Medical Marijuana Laws: How to Remove the Threat of Arrest*, 2015).

[5]https://ballotpedia.org/Ohio_Issue_2,_Marijuana_Legalization_Initiative_(2023) (accessed November 13, 2023).

In 2002, proponents tried again with Proposition 203, the Drug Medicalization, Prevention, and Control Act of 2002, which sought to legalize recreational marijuana and medical cannabis, but failed with 42.7% of the vote (Tilleman, 2021). In 2010, legalization proponents tried afresh with Proposition 203, The Arizona Medical Marijuana Act (AMMA), which decriminalized medical marijuana (Aurit, 2012). This initiative narrowly passed with 50.1% of the vote and established a limited number of nonprofit dispensary licenses (125), in addition to decriminalizing small amounts of medical marijuana (Aurit, 2012). Arizona's AMMA was conservative compared to other states in granting only 125 dispensary licenses, compared to Colorado's 800 dispensaries and nearly 1000 in the city of Los Angeles (Aurit, 2012).

The effort to legalize recreational marijuana in Arizona continued in 2016 with Proposition 205, The Arizona Marijuana Legalization Initiative, which would have legalized small amounts of marijuana and established a system of taxation to fund schools and substance abuse programs ("Arizona Marijuana Legalization, Proposition 205 (2016)", 2016). Special interest groups created dueling ad campaigns highlighting their arguments for and against 205. For example, the *No to 205* group, led by Arizonans for Responsible Drug Policy, cited the threats to children of marijuana chewables, while the *Yes to 205* group focused on the funding source of opposition groups—pharmaceutical companies fearful that expanded marijuana access would cut into their profits, including those derived from opiate-based painkillers (Fischer, 2016; Koehle, 2016). Proposition 205 was unsuccessful, garnering 48.7% of the vote (Berman & Kreit, 2020).

Proposition 207, the Smart and Safe Act, was approved by Arizona voters on November 3, 2020, with 60.03% of the vote.[6] The approved ballot measure legalized the sale of limited quantities of recreational marijuana and the ability to grow no more than six plants for personal use in a person's primary residence (Smart and Safe Arizona Act, 2019). The new legislation permitted adults (21+) to possess up to an ounce of marijuana and established licensing and regulatory systems for cannabis sales (Berman & Kreit, 2020). Proposition 207 established a 16% marijuana excise tax, in addition to the existing transaction privilege and use taxes (Smart and Safe Arizona Act, 2019). Marijuana tax revenues were set to be divided between fire and community college districts; municipal fire, police, and sheriff departments; Arizona's Highway User Revenue Fund; and a new Justice Reinvestment Fund (Smart and Safe Arizona Act, 2019). The Justice Reinvestment Fund, which was to receive 10% of tax revenues, was established to fund public health needs, crime reduction efforts, and decarceration in disadvantaged communities (Berman & Kreit, 2020). The new law was also designed to attempt to address the harms associated with marijuana prohibition, such as unequal policing and incarceration, by allowing the expungement of certain marijuana convictions (Berman & Kreit, 2020). An important clause in Proposition 207 gave local governments control over elements of the regulation, zoning, and licensing of marijuana sales and the power to ban marijuana facilities and testing centers (Smart and Safe Arizona Act, 2019). This meant that local governments were granted the power to shape the local implementation of Proposition 207 in ways that might not match the intent of voters who approved the ballot measure.

Proposition 207 provided a limited number (169) of licenses for marijuana dispensaries (Cochrane, 2021). Many of these were dual licenses that applied to the 125 medical marijuana dispensaries licensed in 2010 under Proposition 203 (Smart and Safe Arizona Act, 2019). Despite the limited licenses, marijuana sales took off rapidly in Arizona. According to an industry study, 2600 marijuana jobs were created in Arizona in 2021, for a total of 23,333 full-time Arizona cannabis jobs (Barcott et al., 2022). The same industry report indicated

[6]https://ballotpedia.org/Arizona_Proposition_207,_Marijuana_Legalization_Initiative_(2020)#cite_note-text-1 (accessed December 31, 2022).

that "Arizona's licensed adult-use stores and medical dispensaries sold a total of $1.35 billion in cannabis products in 2021, $320 million more than the state's medical-only dispensaries sold in 2020" (Barcott et al., 2022, p. 14). In 2022, an additional 26 licenses were awarded in a drawing called the Social Equity Allocation established by Proposition 207 (Smart and Safe Arizona Act, 2019). These licenses were supposed to be awarded to people from communities that had borne undue burdens of marijuana enforcement over past decades (Orenstein, 2020). This allocation occurred in May 2022 and turned out to be highly controversial, with allegations that corporate players ended up with many of the licenses (Schwenk, 2022a, 2022b).

The ballot measure's social impacts appeared to lag behind the economic impacts. For example, as of September 2021, although 3600 petitions for expungement had been granted (with approximately 500 petitions filed per week), there remained between 250,000 and 500,000 cases potentially eligible for expungement (Martillaro, 2021). This slow rate of expungement was attributed to a lack of understanding regarding expungement and complex paperwork, despite several organizations offering assistance pro bono (Martillaro, 2021). In 2023, the Arizona Court of Appeals expanded the number of cases eligible for expungement (Schwenk, 2023). In addition to delays in expungements, there were also concerns regarding law enforcement agencies using loopholes in the legislation, such as whether or not it applied to arrests made on federal highways, to continue drug enforcement policies the proposition promised to end (Abbott, 2022). While industry groups highly publicized the economic benefits of Proposition 207, many of the promised social changes advanced at a much slower pace.

Prior research on public attitudes toward marijuana

Opinion polls are frequently taken to gauge support for marijuana legalization. According to a Pew Research Center survey from April 2021, 60% of Americans believed recreational and medical marijuana should be legal, and another 31% believed medical marijuana should be legal (Schaeffer, 2021). Only 8% of Americans believed the drug should be completely illegal (Schaeffer, 2021). Longitudinal polling indicated that support for recreational marijuana legalization increased in the United States across demographic groups over time (Schaeffer, 2021).

Previous research regarding recreational marijuana legalization ballot measures in other states has typically utilized surveys taken by phone (Collingwood et al., 2018; McGinty et al., 2017; Subbaraman & Kerr, 2016, 2017) or via the Internet (Nielsen, 2010) with questions designed to measure support for recreational marijuana legalization. An alternative approach is to use voting outcomes at the county (Beltz et al., 2020) or precinct level (Branton & McGauvran, 2018). Researchers have used several demographic variables to understand support for marijuana legalization ballot measures, including race/ethnicity, age, gender, income, education, and "urban-ness" (Beltz et al., 2020; Collingwood et al., 2018).

Predictors of support for, and opposition to, recreational marijuana

To build a statistical voting model for Arizona, we first reviewed the existing literature regarding recreational marijuana voting in other states. Here, we summarize how various demographic variables have performed in predicting support for recreational marijuana legalization.

Age

In previous studies, age was negatively related to support for recreational marijuana legalization; older cohorts were typically more conservative in their views of marijuana (Beltz et al., 2020; Collingwood et al., 2018; Habecker & Bevins, 2022). Opinion polls mirror academic studies regarding age and marijuana legalization. A Pew Research Center survey from April 2021 indicated that only 32% of adults 75 and older supported medical and recreational marijuana legalization (Schaeffer, 2021). However, younger cohorts tended to support recreational marijuana legalization; this support was typically attributed to a higher likelihood of having smoked marijuana, more liberal attitudes associated with younger voters, and eagerness to participate in the fast-growing marijuana economy (McCarthy, 2015; Perez et al., 2019). Support among younger cohorts appeared in both opinion polls (Brenan, 2020; Geiger, 2016; Schaeffer, 2021) and academic research (Beltz et al., 2020; Collingwood et al., 2018; Habecker & Bevins, 2022).

Education

Several studies reported a positive relationship between higher educational attainment and support for recreational marijuana legalization (Beltz et al., 2020; Collingwood et al., 2018; Nielsen, 2010; Subbaraman & Kerr, 2016). Denham (2019) argued that people with more education may support marijuana legalization due to a higher awareness of news regarding medical uses, patterns of decriminalization, and the costs of incarcerating low-level drug offenders. Academic research results mirrored national opinion polls, indicating that people with more education tended to support recreational marijuana legalization (Brenan, 2020; Geiger, 2016).

Ethnicity/race

Marijuana legalization is a multi-faceted issue that includes not only economic arguments related to job creation and tax revenues but also arguments related to prison reform, social justice, and social equity (Berman & Kreit, 2020). Race and ethnicity were important variables in marijuana ballot measure studies due to the inequities associated with the costs and benefits of illegal and legal marijuana. In areas where marijuana was illegal, Blacks and Hispanics, although their use was comparable to that of Whites, were more likely to be arrested for marijuana (Edwards et al., 2013, 2020). Disparities based on race also existed in sentencing for marijuana offenses. Although results varied geographically, Blacks and Hispanics were more likely to be incarcerated and received longer sentences for comparable marijuana offenses than Whites (Brennan & Spohn, 2008; Curry & Corral-Camacho, 2008; Pasko, 2002). In several states, Hispanics received the harshest drug sentences, perhaps due to the association between Hispanics and the Latin American origins of much of the international drug trade (Brennan & Spohn, 2008; Pasko, 2002). A study of court records of all the cases handled by the Maricopa County (AZ) Attorney's Office from January 1, 2013, through December 31 by the Arizona chapter of the ACLU produced similar findings (Ortiz & Kovacs, 2020). The ACLU found that Hispanics were sentenced to significantly longer jail and prison terms for simple marijuana possession than Blacks and Whites (Ortiz & Kovacs, 2020). They also found that Blacks consistently received longer prison, jail, and probation sentences for personal drug paraphernalia possession charges than Whites or Hispanics (Ortiz & Kovacs, 2020).

There was less in the marijuana enforcement literature regarding Native Americans. However, according to one study, Native nations have also experienced targeted differential

marijuana enforcement when tribal laws conflict with federal laws in ongoing sovereignty conflicts (Lewis, 2019). Native communities that wanted to legalize marijuana (or non-psychoactive hemp production) often met with heavy-handed federal enforcement despite the supposed autonomy of many tribal areas (Lewis, 2019).

Opinion polls indicated race/ethnicity played a role in shaping perceptions regarding legalizing medical *and* recreational marijuana. Three opinion polls taken over time showed consistent differences in support based on race/ethnicity—Whites 2016 (59%), 2021 (63%), 2023 (60%); Blacks 2016 (59%), 2021 (65%), 2023 (68%); and Hispanics 2016 (46%), 2021 (52%), 2023 (49%) (Geiger, 2016; Schaeffer, 2021, 2023). While support remained consistently above 50% for Whites and Blacks over time, Hispanics showed the lowest average support. In another poll, foreign-born Hispanics were half as likely to support marijuana legalization (27% vs. 57%) than those born in the United States (Lopez et al., 2014). Race/ethnicity also shaped opinions regarding marijuana decriminalization. In a 2023 poll, Blacks (74%), Whites (69%), and Hispanics (56%) varied in their overall support for releasing people from prison charged with marijuana-only-related offenses (Schaeffer, 2023). Opinions regarding support for expunging marijuana-related convictions also varied by race/ethnicity: Blacks (74%), Whites (63%), and Hispanics (52%) (Schaeffer, 2023). Native American perceptions of marijuana legalization were absent in these national polls. While Blacks and Hispanics had common experiences related to excessive marijuana policing, the two groups appeared to have widely varying attitudes toward legalization, with Black populations showing consistently more support. At the same time, while Whites have been policed the least and arguably received the most significant benefits from legalization, their opinions hovered between the other two groups. The role of race in marijuana legalization voting behavior remains an important (and complex) variable to consider in voting behavior studies.

Gender

The effects of gender on recreational marijuana voting appeared more mixed. In some opinion polls, men were slightly more supportive of legalization than women (Brenan, 2020; Geiger, 2016), and in an analysis that combined polling and marijuana use data, Elder and Greene (2018) found that men reported using marijuana more than women. However, the predictive power of gender regarding recreational marijuana support was mixed in academic research; some scholars reported no relationship (Subbaraman & Kerr, 2016, 2017), while others found a positive association between males and support for marijuana legalization (Beltz et al., 2020). Other scholars found a positive association with females (Collingwood et al., 2018). However, all these studies used models with different covariates, so comparisons were difficult.

Income

Previous studies indicate a nuanced relationship between income and marijuana legalization voting behavior. First, people in precincts with lower median incomes may have voted in favor of legalization in anticipation of job creation and economic development (Branton & McGauvran, 2018). At the same time, people in affluent areas with less need for job creation may have been more swayed by arguments that associate marijuana legalization with crime (Branton & McGauvran, 2018). However, in a 2020 Gallup Poll, support for marijuana legalization rose along with incomes, with those in the $100,000+ group showing the highest support (Brenan, 2020), so the conditioned association between income and marijuana support needs further investigation.

Smoking

Researchers have studied the links between marijuana and tobacco use, particularly the relationship between co-use and increased nicotine dependence (Wang et al., 2016; Wang & Cataldo, 2016). These studies indicate that in states with legal medical marijuana, cigarette smokers who also use marijuana may increase their dependence on nicotine at higher rates than in states without legal medical marijuana (Wang et al., 2016; Wang & Cataldo, 2016). Another study suggested that co-use was already increasing (from 2003 to 2012) and should be monitored closely after widespread legalization (Schauer et al., 2015). Previous studies have not measured the linkages between smoking cigarettes and marijuana voting preferences. Measuring the relationship between smoking prevalence in voting precincts and support for marijuana legalization may also contribute to understanding the linkages (or lack thereof) between the use of the two substances.

Rurality/population density

There is a glaring rural/urban divide in U.S. politics, with urban areas trending Democratic and liberal and urban areas trending Republican and conservative (Damore et al., 2021; Scala & Johnson, 2017). Due to this rural–urban polarization, some scholars of marijuana legalization included rurality and population density variables in their analyses. This is arguably a better explanatory variable to include in the model than a direct voter preference variable for one particular party because of the circularity introduced by the latter. Rural residents tend to be more conservative in their social perspective than their urban counterparts. Hence, a population density variable should account for political differences between rural and urban precincts. In a study of support for recreational marijuana in Nebraska, Habecker and Bevins (2022) found less support for legalization in rural areas than urban areas. However, in a multi-state analysis, Beltz and others (2020) found that rurality did not predict county-level recreational marijuana support.

Political affiliation

Researchers sometimes used political affiliation, often operationalized as the percent of the unit of analysis (county, precinct, etc.) that voted for a particular political party, to understand ballot measure support and opposition (Branton, 2003; Beltz et al., 2020). In this case, Republican voters might have opposed recreational marijuana legalization due to conservative and religious beliefs regarding drugs (Beltz et al., 2020; Collingwood et al., 2018) or simply because they believe Democrats supported such legislation. Some opinion polls have indicated that Democrats were more likely to support marijuana legalization than Republicans by as much as a 2 to 1 margin (Brenan, 2020; Geiger, 2016; Schaeffer, 2021). However, including a political affiliation variable in our analysis of Proposition 207 was problematic because it appeared to cause circularity issues in the model. Essentially, the variables identified as significant factors in voting for marijuana legalization were the same variables that could account for a vote for either the Republican or Democratic party. This led to severe issues with multicollinearity and misspecification bias in the parameter estimates associated with the demographic variables.[7] Consequently, a political affiliation variable was not included in the MGWR portion of our analysis. However, we used political affiliation variables in two secondary analyses: (a) OLS regression models of the MGWR

[7]We confirmed this to be the case by adding a percentage vote for the Democratic party from the 2020 presidential election to the model. The parameter estimates for many of the remaining variables were nonsensical, particularly at the local level.

intercept and residuals and (b) a Boolean mapping exercise. These secondary analyses are presented after the MGWR analysis below.

Based on our literature review, we developed the following hypotheses regarding the determinants of support for recreational marijuana legalization.

Hypothesis 1-1. The higher the percentage of people aged 18–29 per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 2-1. The higher the percentage of people aged 65–85+ per voting precinct, the *lower* the support for Proposition 207, ceteris paribus.

Hypothesis 3-1. The higher the percentage of people aged 25+ with at least a bachelor's degree per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 4-1. The higher the percentage of Blacks per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 5-1. The higher the percentage of Hispanics per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 6-1. The higher the percentage of Native Americans per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 7-1. The higher the percentage of males per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 8-1. The higher the median household income per voting precinct, the *lower* the support for Proposition 207, ceteris paribus.

Hypothesis 9-1. The higher the percentage of people who smoked cigarettes in the last 12 months per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Hypothesis 10-1. The higher the population density per voting precinct, the *higher* the support for Proposition 207, ceteris paribus.

Previous analyses of ballot-issue voting behavior have primarily used global statistical models such as OLS regression or spatial error models that make it impossible to detect spatial variations in the way sociodemographic attributes affect voting behavior. Here, we used the variables discussed above from previous marijuana legalization research and listed in detail in Table 1 as predictors of support for Proposition 207 in both a global and local model, the former being used to benchmark the results of the local model calibration.

METHODS

Data and model benchmarking with OLS

Previous research on spatial voting behavior has primarily used state or county-level election data. At this scale of analysis, local voting behaviors are challenging to identify, particularly

TABLE 1 Description of the variables included in the study.

Variable name	Definition	Mean	Min	Max
Prop 207 yes[a]	% voting yes	60.2	24.8	89.2
Age 18–29	% age 18–29	15.6	.12	97.7
Age 65+	% age 65+	20.3	.04	91.9
25+ bachelor's	% 25+ with at least a bachelor's degree	18.3	0	52
Black	% Black	3.9	0	34.8
Hispanic	% Hispanic	29.3	.55	99.4
Native American	% Native American	7.41	0	98.8
Male	% male	49.3	38.2	58.7
Med HH income	Median household income	64,132	13,623	200,001
Smoke cigs	% smoked cigarettes in last 12 months	16.9	5	36.9
Pop density	Population density (pop per square mile)	3024.2	.2	19,991.2

Note: All explanatory variables were obtained from the ESRI 2020 Business Analyst.
Source: a. https://azsos.gov/2020-election-information (accessed September 8, 2021).

in the western United States, which has large county polygons. In this analysis, we use the 1488 voting precincts of Arizona, the smallest unit available for voting analysis.

We obtained the 2020 Arizona election data from the Arizona Secretary of State website and converted these voting data from counts to percentages.[8] We joined the voting data to the 2020 Arizona voting precinct polygon shapefile obtained from the Harvard Dataverse (Voting and Election Science Team, 2020). Voting precincts with fewer than 200 population were removed to reduce small-number bias in percentages. We also removed precincts with prisons and other incarceration facilities because they radically skewed gender percentages and because incarcerated people typically lose voting privileges. This left a total of 1433 voting precincts.

Researchers have a long history of using geographic census data to answer voting behavior questions (Gosnell & Gill, 1935; Miller et al., 1974; Ogburn & Goltra, 1919). However, mismatched census and voting polygons can complicate analyses and lead to inaccurate results (Amos et al., 2017). Several approaches have been used to create data sets that combine census data with voting precinct polygons, including areal weighting, dasymetric mapping, point kriging, and kriging-based areal interpolation (Amos et al., 2017). In a recent study, Amos and others (2017) determined that dasymetric mapping techniques were the most appropriate to construct more accurate and realistic weights for areal weighting in voting precinct polygons. In the ESRI suite of GIS tools, such as ArcGIS Pro, geoenrichment tools utilize dasymetric apportionment techniques to aggregate census-based demographic data for smaller areas. The algorithm uses data from census block points to apportion data to polygons.[9] We used the ESRI Business Analyst 2020 data and the geoenrichment tool in ArcGIS Pro to enrich the Arizona 2020 voting precinct polygons with the variables shown in Table 1.[10]

Figure 2 describes the distribution of the dependent variable (Proposition 207 Yes) from which it can be seen that support for Proposition 207 varied from 24% to 90% across precincts in Arizona.

[8]https://azsos.gov/2020-election-information (accessed September 8, 2021).
[9]https://developers.arcgis.com/rest/geoenrichment/api-reference/data-apportionment.htm.
[10]ESRI's business analyst includes data from various sources, including the U.S. Census. https://doc.arcgis.com/en/business-analyst/web/data.htm.

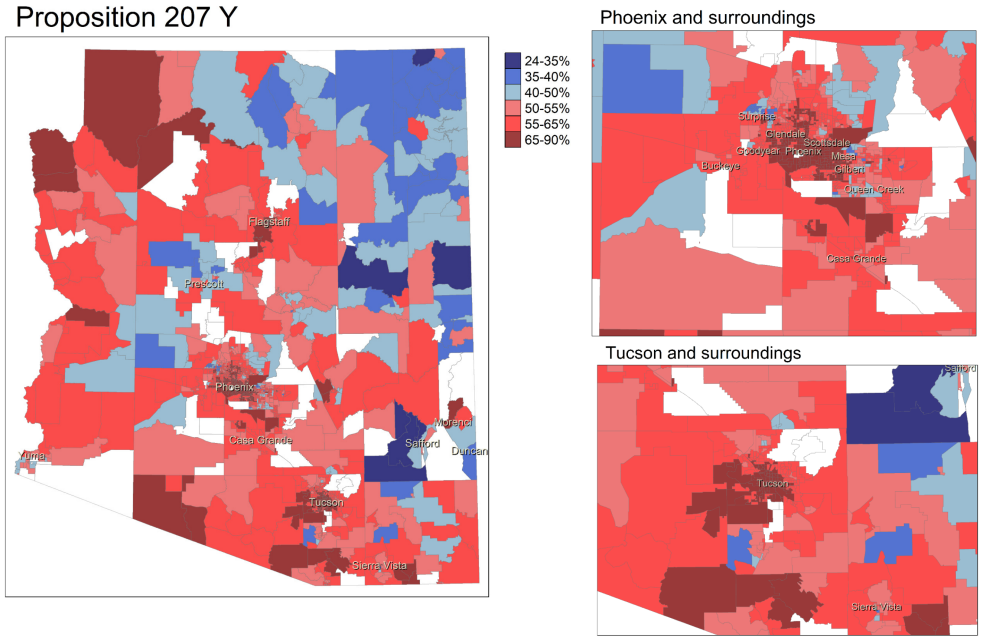

FIGURE 2 Percent voting in favor of Proposition 207.

The spatially clustered nature of the voting pattern suggests that support for Proposition 207 was not random and we now attempt to determine what factors influenced support.

OLS regression models of voting data

All the variables in Table 1 were standardized to have mean 0 and variance 1. This step aids in the interpretation of the bandwidths in the subsequent MGWR calibration and also allows the magnitude of the parameter estimates to depict the strengths of the associations between each covariate and voting yes on Proposition 207. Using all ten covariates, we first calibrated a traditional global model of voting yes on Proposition 207, the results of which are shown in Table 2. No multicollinearity was detected across the covariates in this model—all the variance inflation factors were below 6.

The conditioned associations reported in Table 2 are all statistically significant and largely coincide with our understanding from previous research. For example, younger voters (aged 18–29) tended to support the proposition while older voters (aged 65+) opposed it, ceteris paribus. There was a strong association between education (25+ with at least a bachelor's degree) and support for Proposition 207. There were positive associations between Black and Hispanic ethnicity and support for Proposition 207 but a negative association between Native American ethnicity and support for the proposition. While the association between income and support for marijuana legalization in polling and previous research is mixed, there was a significant negative relationship between income and Proposition 207 support here. While previous research has produced mixed inferences regarding population density and support for recreational marijuana, here, the association was significantly positive. There was also a positive association between people who had smoked cigarettes in the last 12 months and support for Proposition 207. The results supported all our hypotheses except that regarding the attitudes of Native Americans, which tended to be negative on the proposition.

TABLE 2 OLS regression results.

Variable	Est.	SE	*t* (Est/SE)	*p*-Value
Intercept	−.000	.018	−.000	1.000
Age 18–29	.188	.028	6.716	.000
Age 65+	−.139	.032	−4.319	.000
25+ bachelor's	.459	.032	14.422	.000
Black	.199	.022	9.025	.000
Hispanic	.137	.029	4.722	.000
Native American	−.090	.026	−3.467	.001
Male	.087	.022	4.003	.000
Med HH income	−.297	.036	−8.176	.000
Smoke cigs	.127	.027	4.808	.000
Pop density	.201	.024	8.501	.000
AICc	3009			
R^2	.53			
Adj. R^2	.53			

Previous efforts to study support for recreational marijuana that employed OLS regression models reported a large range of goodness-of-fit with R^2 values ranging from .19 to .85 (Beltz et al., 2020; Collingwood et al., 2018). Our model is somewhere in the middle of this range suggesting that although regularities in voter support exist, there could be a substantial amount of randomness in voting behavior or the processes being modeled are not constant over space as is assumed by the global model. To examine this latter issue, we turn to the results of calibrating a local form of the same model.

Multiscale geographically weighted regression

MGWR is the latest advance in the family of regression-based, data-borrowing, local models that includes geographically weighted regression (GWR) and semi-parametric GWR (Fotheringham et al., 2017, 2023). While GWR assumes that all the processes being modeled vary at the same spatial scale, and semi-parametric GWR allows processes to be divided into two types: those that vary at the same spatial scale and those that are global, MGWR allows each process being modeled to vary over different spatial scales (Fotheringham et al., 2017). Unlike GWR, MGWR calculates an optimal bandwidth for each process being modeled, and this covariate-specific bandwidth, bwj, controls the spatial extent over which data are borrowed (and weighted) to enable a local calibration at each location (Fotheringham et al., 2022). The general form of an MGWR model is:

$$y_i = \beta_{0i} + \beta_{1i}x_{1i} + \beta_{2i}x_{2i} + \ \ldots \ + \beta_{ki}x_{ki} + \epsilon_i \tag{1}$$

In this general expression, y_i represents the recorded value of the dependent variable % vote yes for Proposition 207 at location i, x_{ki} is an observation of the kth explanatory variable at location i, β_{ki} is the kth parameter estimate which is specific to location i, and ϵ_i is a random error term. Each set of local parameter estimates (β_{ki} for all i), is estimated by deriving the optimal number of nearest neighbors around i from which to borrow and weight data. This is known as the covariate-specific bandwidth and its magnitude relative to the total number of data locations is indicative of the spatial scale over which each process varies. Larger bandwidths

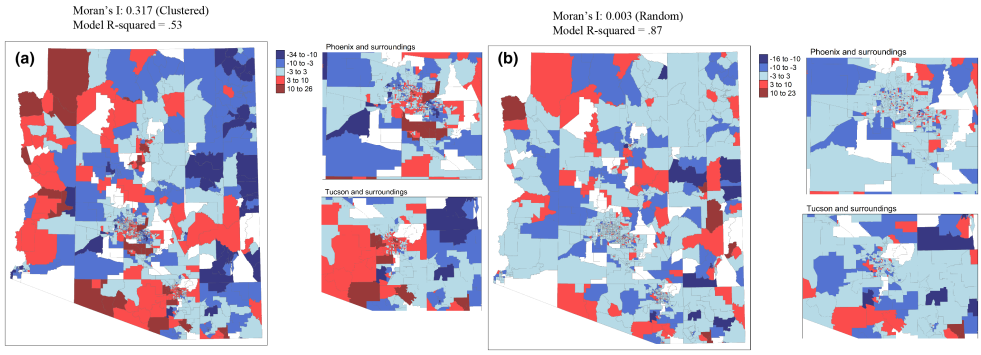

FIGURE 3 The spatial distribution of residuals: (a) from the global OLS model (Moran's $I = .317$; p-value = .000); (b) from the local MGWR model (Moran's $I = .003$; p-value = .57).

indicate spatially invariant processes; smaller bandwidths indicate processes that vary more locally (Fotheringham et al., 2023).

The statistical advances of MGWR allow a more nuanced understanding of spatial processes by quantifying the spatial variability of the processes (conditioned associations) that affect the spatial distribution of some phenomenon—in this case, voting support for Arizona Proposition 207. An MGWR calibration produces a set of local parameter estimates for each conditioned relationship being modeled, rather than a single average estimate. These local estimates can be mapped and subject to further analysis to ascertain if the modeled processes vary significantly over space.

To achieve a comparable bandwidth for all relationships being modeled, the variables in the model need to be standardized, as described above (Oshan et al., 2019). This standardization also generates estimates of the local intercept, which can be interpreted as the raised or lowered support for the dependent variable (% support for Proposition 207) conditional upon the demographic composition of each polygon being the same (i.e., all covariates have a value of zero, indicating all polygons have an average value of each covariate). Positive (negative) estimates of the local intercept indicate polygons where there is a stronger (weaker) support for Proposition 207 than would be expected given the population composition of that polygon. In effect, the local intercept estimates measure local contextual effects—those indefinable or unmeasurable attributes of places that are independent of sociodemographic composition but which affect people's voting behavior (Fotheringham et al., 2021, 2023).

Because of its ability to model spatially varying processes and to quantify and separate the effects of geographical context, there is a rapidly growing body of MGWR applications. Researchers have used MGWR to answer spatial questions related to health issues such as obesity (Oshan et al., 2020), overall causes of mortality (Cupido et al., 2021), crowdsourced landscape perceptions (Chien et al., 2020), Airbnb rentals (Shabrina et al., 2020), and air pollution levels in China (Fotheringham et al., 2019). MGWR has also been used to study elections and voting behavior to identify how the differences between local and global processes, particularly the role of geographical context, influence voting in presidential elections (Fotheringham et al., 2021; Li & Fotheringham, 2021).

MGWR results

The local model was calibrated using MGWR 2.2 (Oshan et al., 2019), freely available software downloadable at https://sgsup.asu.edu/sparc/mgwr. As expected, the MGWR calibration yielded a far more accurate replication of the voting percentages in each precinct: the

TABLE 3 Optimized bandwidths ($N = 1433$).

Variable	Bandwidth
Global	
MedHHInc2020***	940
PctAge65+***	861
Pct25Bach2020***	761
Regional	
PctMale2020***	256
PctAge18–29***	220
PctBlack2020***	199
PopDens2020***	179
SmkCg12***	172
PctHisp2020***	134
Local	
PctNat2020***	74
Intercept***	43

***$p = .001$.

adjusted R^2 value increased from .53 to .87, and the corrected Akaike information criterion value decreased from 3007 to 1608. The model also yielded residuals with little or no spatial dependence, as illustrated in Figure 3b, where the Moran's *I* value for the residuals was .003 (insignificant), compared to .317 (significant clustering) for the global model residuals shown in Figure 3a. The spatial dependency in the global model residuals reduces confidence in the inferences reached from the model calibration.

Calibration of the model by MGWR yields a set of local parameter estimates for each conditioned relationship being modeled (plus for the intercept).[11] It also yields an optimized bandwidth associated with each set of local parameter estimates, indicating the degree to which the modeled processes exhibit spatial nonstationarity. These optimized bandwidths are reported in Table 3, along with a subjective categorization of the associated local parameter estimates as not varying over space (global), varying regionally and locally.

The results reveal some of the added value of MGWR provided by bandwidth measures. Several conditioned associations involving support for Proposition 207, income, education, and age, were essentially constant over space (i.e., global). The others exhibited spatial heterogeneity of varying degrees. Most of these associations varied slowly across the state except for the percentage of Native Americans and the intercept, which exhibited strong spatial heterogeneity and had very small bandwidths. It is particularly interesting that the intercept exhibited strong heterogeneity because it measures the effect of local context on voting. To see these "hidden" variations in local parameter estimates more clearly, we can map the local parameter estimates. We do this for a selection of parameter estimates—there is no need, for example, to map the estimates which are essentially constant over space.

Figure 4 shows the geographic variation of the local parameter estimates associated with the percent Hispanic variable. Red polygons indicate precincts in which support for Proposition 207 was significantly positively associated with percentages of Hispanics; blue polygons indicate precincts where support for Proposition 207 was significantly negatively

[11]Following Sachdeva and others (2021), we tested the variables and parameter estimates for nonlinearity and found that they do not reflect nonlinear conditioned relationships between *y* and *x*.

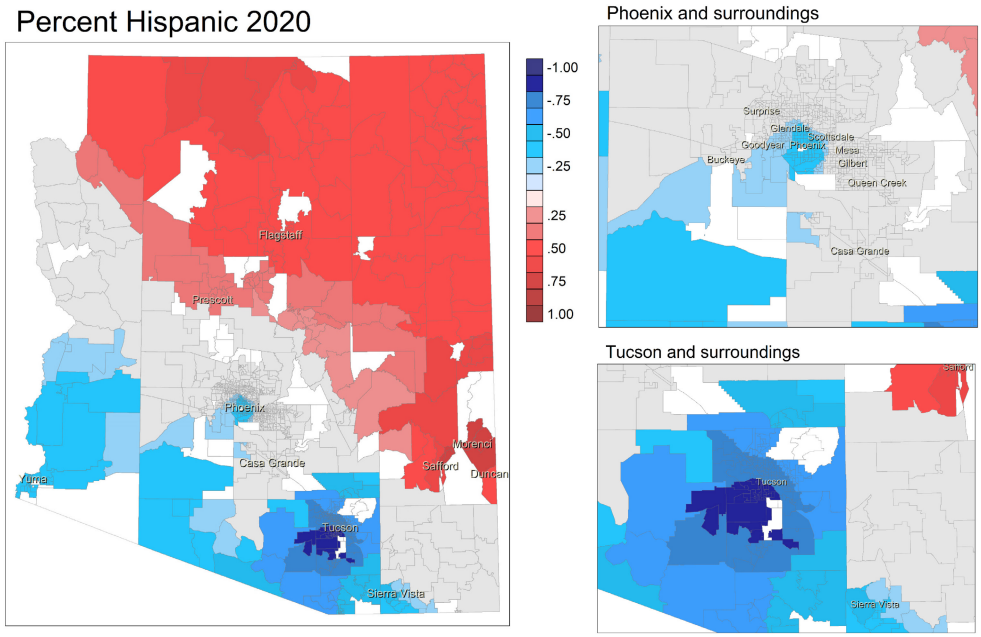

FIGURE 4 Spatial distribution of the local parameter estimates associated with the covariate % Hispanic population (OLS estimate = .137).

associated with the percentage of Hispanics. Polygons shaded gray are areas where there is no significant relationship between voting on Proposition 207 and the percentage of Hispanic population. While global models are blind to such differences, MGWR reveals that the relationship between Hispanics and support for Proposition 207 was spatially nuanced. In this case, proximity to the Mexican border may have influenced the opposition of Hispanics to Proposition 207. In their spatial analysis of voting behavior, Branton and others (2007) found that Anglo-Democrats living nearer to the California-Mexico border were more likely to support immigration-restricting ballot measures than Anglo-Democrats residing farther from the border. They attributed this voting behavior to the lived experience of Democrats whose proximity to the border negatively shaped their immigration views (Branton et al., 2007). Due to the flows of illegal drugs (including marijuana) over the United States–Mexico border over the decades, people living nearer to the border might vote differently regarding marijuana legalization than those living farther away. Many Hispanics in U.S. border communities have family and friends living in Mexico (Martínez, 1994), where thousands of people have been murdered in cartel violence (Shirk, 2010). They may have also been far more aware of the chaos in Mexican border communities that had become cartel war zones, which may have caused them to oppose marijuana legalization. Perhaps the stigma linking Hispanics to the Latin American drug trade and their proximity to the United States–Mexico border shaped the tendency of Hispanics in southern Arizona, particularly near Tucson, to vote against Proposition 207 in higher numbers than Hispanics living elsewhere in Arizona. MGWR parameter maps help pinpoint areas where a more in-depth investigation of voting behavior is warranted.

Figure 5 illustrates another example of spatial heterogeneity in Proposition 207 voting behavior—specifically clusters of opposition and support of Native American voters in Arizona. According to the 2020 census, approximately 319,512 Native Americans lived in Arizona, or about 4.5% of the state population of 7,151,502.[12] Arizona contains 21 federally recognized tribal

[12]https://data.statesmanjournal.com/census/total-population/not-hispanic-white/arizona/040-04/ (accessed January 4, 2023).

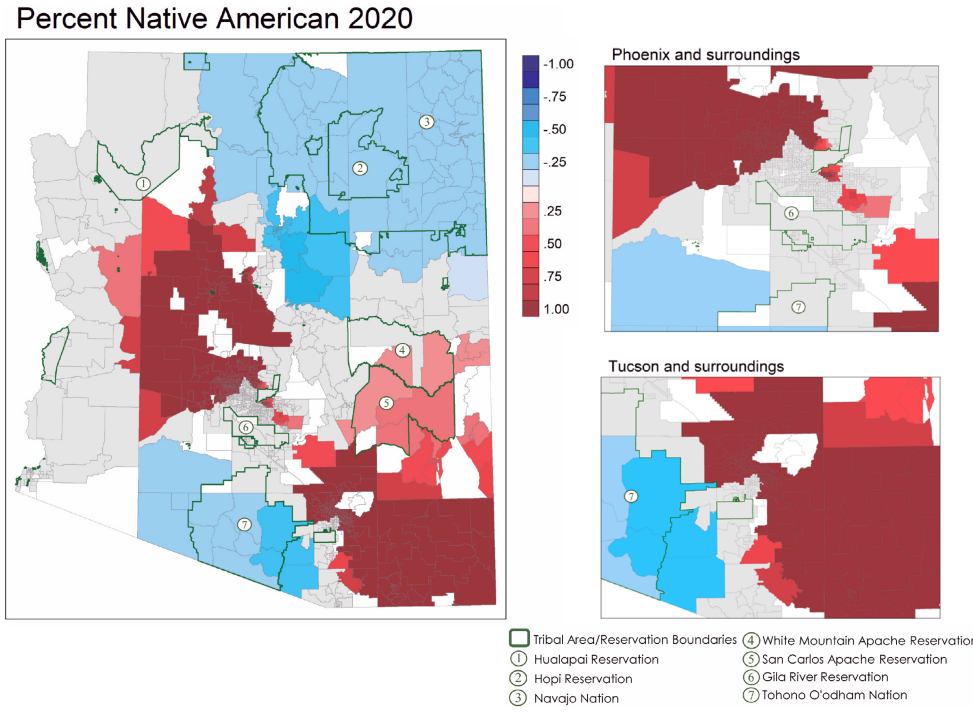

FIGURE 5 Spatial distribution of the local parameter estimates associated with the covariate % Native American population (OLS estimate = −.09).

lands and reservations covering approximately 43,212.03 square miles.[13] The clusters of Native American opposition (blue precincts) to Proposition 207 fell primarily within the boundaries of larger reservation areas, such as the Navajo (Diné) areas in Northern Arizona and the Tohono O'odham Nation reservations in Southern Arizona. Several news articles indicated an ongoing opposition to marijuana legalization among Navajo (Diné) law makers, who enacted several laws opposing marijuana sales and growing on their lands before the 2020 election ("Bill against legal marijuana advances in Navajo Nation Council," 2015; Cegielski, 2015; "Navajo lawmakers continue to say 'no' to marijuana," 2015). These laws were inspired by concerns over increases in crime rates and addiction problems on reservation lands (Keane, 2022) and because marijuana consumption conflicted with Navajo (Diné) tradition and values (Cegielski, 2015).

An additional reason for the observed spatial variations in the conditioned relationship between the Native American population and support for Proposition 207 is that many young Navajo (Diné) leave reservations for urban areas in search of education and employment (Weaver, 2012), which may mean there were higher proportions of elderly voters and those below voting age on reservation lands. If on-reservation voting blocs tended to skew more elderly, this may also help explain the lower support for recreational marijuana in these areas. The opposite effect may have occurred with Native American voting outside reservation areas, where there was support for Proposition 207. In these areas, Native American populations were often composed of younger people, who may have been more inclined to support marijuana legalization due to their age.

One exception to this general explanation is the San Carlos Apache reservation area, which had higher concentrations of Native American inhabitants who voted in favor of Proposition

[13] https://en.wikipedia.org/wiki/List_of_Indian_reservations_in_Arizona (accessed February 18, 2023). Some of these areas include lands in neighboring states.

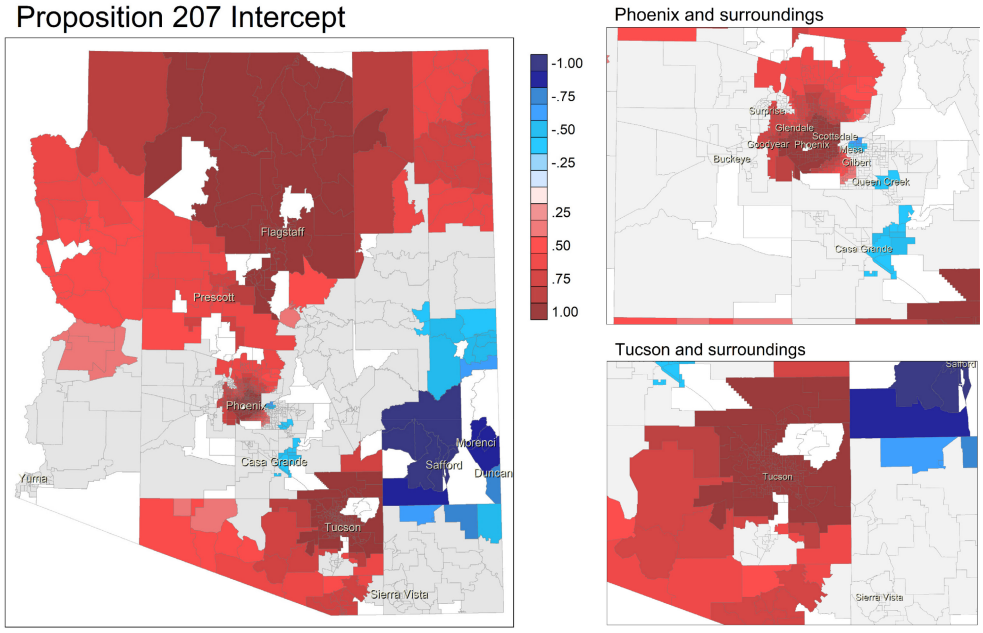

FIGURE 6 Spatial distribution of the local estimates of the intercept (OLS estimate = 0).

207. On May 18, 2020, the San Carlos Apache tribe approved Resolution No. MY-20-071, which legalized the production of hemp on tribal lands for commercial purposes (San Carlos Apache Tribe of Arizona Hemp Plan, 2020) and may have led to increased support for Proposition 207 in the San Carlos reservation. These MGWR parameter maps help identify areas where local variations in Native American opposition to and support for recreational marijuana legalization merit further research.

MGWR calibration also generates local estimates of the intercept, which identify polygons with raised or lowered support for Proposition 207 *conditional upon the demographic composition of each polygon*. Because all the variables in the model are standardized with mean 0 and standard deviation 1, the local intercept indicates the level of support for Proposition 207 that would occur if that polygon contained an average population composition (i.e., the estimate of the local intercept is the value of y when all the independent variables are zero, which would happen if they had exactly the average value of each covariate). Positive values of the local intercept estimate hence indicate precincts where voting for Proposition 207 is higher than expected, given the population composition of those precincts. Negative values of the local intercept estimates indicate precincts where support for Proposition 207 is less than expected, given the population composition of those polygons. The local intercept estimates measure local contextual effects—those indefinable or unmeasurable attributes of places independent of sociodemographic composition. By separating place effects from the effects of individual sociodemographic attributes, we can compare how geography and sociodemographic variables shape voting behavior.

The MGWR local estimates of the intercept (see Figure 6) enable us to identify precincts that would either support (dark red) or oppose (dark blue) Proposition 207 even if all the precincts contained exactly the same mix of population. That is, these values demonstrate support above or below what would be expected, given the population composition of each precinct. We refer to this as "*intrinsic*" support for, or opposition to, the proposition. The areas shaded gray show no intrinsic preference either for or against Proposition 207, and the

vote for the proposition reflects the population composition of these precincts. The distribution in Figure 6 indicates that large swathes of Arizona had intrinsic support for legalizing recreational marijuana. This is particularly true for the urban areas of Phoenix, Tucson, and Flagstaff. There is something about the communities in these urban areas that led them to view the legalization of marijuana more favorably than would be expected, given their population composition and characteristics, including population density. However, the intercept map also identifies areas to the east of Phoenix, as well as the community of Casa Grande between Phoenix and Tucson, where there was an intrinsic opposition to Proposition 207. The two small blue areas adjacent to Phoenix include precincts in the cities of Mesa, Gilbert, and Queen Creek (Figure 6 Phoenix insert), which were founded by Mormons.[14] According to a study on city policy preferences, Mesa is still considered one of the most conservative cities in the United States (Tausanovitch & Warshaw, 2014). In the wake of the passage of Proposition 207, several local governments[15] enacted ordinances to limit the sale of recreational marijuana (Kelety, 2020). Both the Mesa and Gilbert city governments enacted this legislation,[16] which supports the MGWR findings of a local context associated with opposition to Proposition 207 in Figure 6.[17] The largest light blue area between Phoenix and Tucson includes the town of Casa Grande, which also enacted local city ordinances to limit recreational marijuana use and sales in the wake of Proposition 207's passage (Olivera, 2020).[18]

The dark blue area near Arizona's eastern border includes the towns of Safford, Morenci, and Duncan, which had the most intense intrinsic opposition to Proposition 207. These towns are in Graham and Greenlee counties, which are conservative areas with economies based on mining and agriculture. Many of the towns in Graham County were founded as part of a larger Mormon colony in the late 19th century (Williams, 1937). In 2020, approximately 31% of Graham County's population was Mormon, making it the Arizona county with the highest percentage of Mormons, which may help explain the opposition to Proposition 207.[19] Graham County also enacted a set of local ordinances restricting the sale of recreational marijuana in the wake of Proposition 207's approval.[20] Opposition to recreational marijuana in areas with higher concentrations of Mormons is not surprising, given that Mormons are also taught to abstain from caffeine, tobacco, and alcohol. In the months leading up to the November 2020 vote, Mormon church leaders expressed their strong opposition to Proposition 207 in Arizona newspapers (Willis, 2020). However, it must be noted that the Bishops of the Arizona Catholic Conference also publicly opposed Proposition 207 before the election ("Arizona Catholic Conference Bishops' Statement Opposing the Legalization of Recreational Marijuana," 2020). One could perhaps model the opposition to Proposition 207 in various parts of Arizona within a global framework by adding a precinct-level variable related to the prevalence of people who follow the Mormon faith.

[14]The area in light blue has a high concentration of Latter-Day Saints churches, which may explain the intrinsic opposition to Proposition 207 in this area.

[15]These cities included Gilbert, Glendale, Goodyear, Mesa, Scottsdale, and Surprise (Kelety, 2020).

[16]Mesa's city council passed ordinances to limit the sale of recreational marijuana to establishments that held existing dual licenses for medical and recreational marijuana, which were limited to a fixed number statewide by the legislation that legalized medical marijuana in 2010 (Prop 203) and recreational marijuana in 2020 (Prop 207). Mesa enacted additional city ordinances restricting the use of recreational marijuana in public places, public transportation, etc. (see https://library.municode.com/az/mesa/codes/code_of_ordinances?nodeId=COOR_TIT6PORE_CH25MAPR_6-25-4MAESPREX).

[17]Local governments in other states have responded to marijuana legalization by enacting laws and ordinances that prohibit marijuana sales and use (Dilley et al., 2017), which highlights the need for approaches like MGWR that make it possible to identify local trends that are hidden in global statistical analyses.

[18]Casa Grande city 2022 marijuana ordinances. https://codelibrary.amlegal.com/codes/casagrande/latest/casagrande_az/0-0-0-13784 (accessed January 4, 2023).

[19]https://en.wikipedia.org/wiki/The_Church_of_Jesus_Christ_of_Latter-day_Saints_in_Arizona.

[20]https://www.graham.az.gov/DocumentCenter/View/5209/Final-Marijuana-Ordinance-2021-1-PDF?bidId=.

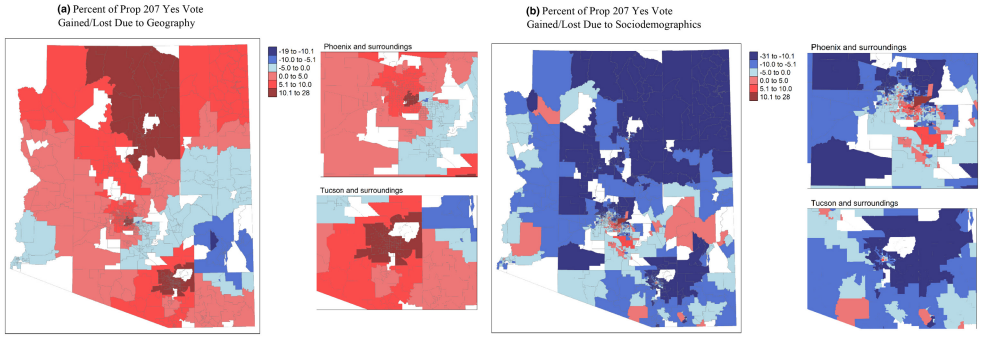

FIGURE 7 (a) Contribution due to geography. (b) Contribution due to sociodemographics.

However, such a variable is not available at this spatial scale and even if it were, the values would be so uniformly low across most of the precincts that its role in the model might be insignificant. The value of MGWR is that such highly localized, unanticipated, effects can be accounted for through the local intercept rather than ignored reducing the chances of omitted variable bias in the other the parameter estimates.

Geographic versus demographic drivers of voting behavior

The estimates of the local intercept, which indicate an intrinsic leaning in favor of or against Proposition 207, can be translated into voting percentages by multiplying each value by the standard deviation of the unstandardized percentage votes for Proposition 207 in each precinct (Fotheringham et al., 2021). These values are shown in Figure 7a. Areas in red show the percent vote that would be added because of geographical context; areas in blue indicate the percentage decrease in vote due to geographical context. These values are independent of the sociodemographic composition of each precinct and represent the pure geographical contextual effect on voting for or against Proposition 207 in Arizona. As can be seen, the effect of geographical context can be substantial in some precincts, being responsible for up to a 19% decline in support in some precincts and up to a 28% increase in votes in favor in others. To be clear, the percentage votes for each precinct depicted in Figure 7a result purely from location and not from the composition and characteristics of the populations in each location. Not including this effect within the model could result in a severe misspecification bias in the parameter estimates associated with the some of the covariates in the model.

It is of interest to contrast the contribution of voting behavior that can be attributed to geographical context with that which can be attributed to the sociodemographic composition of each polygon. The latter can be calculated from Equation (2), where sigma represents a standard deviation and the bar indicates a mean value (Fotheringham et al., 2021).

$$\sigma_y \sum_j \beta_{ik} \frac{\left(x_{ik} - \overline{x}_k\right)}{\sigma_{x_k}} \tag{2}$$

These values are shown in Figure 7b and represent the percentage vote that is added to (red), or subtracted from (blue), the average percentage vote across the precincts and which is due to the sociodemographic composition of each precinct. Throughout large swathes of Arizona, the sociodemographic composition of a voting precinct results in decreased support for Proposition 207 (blue polygons). However, these are largely rural precincts with relatively low populations; the sociodemographic compositions of the large urban precincts tended to

lead to higher support for the proposition (red polygons). The overall contribution of population composition to voting either for or against Proposition 207 tended to be slightly larger than that of geographical context, although the contributions are surprisingly close.

Note that if one adds the percentages in Figure 7a,b to the average vote for Proposition 207 across the state (60.23%), the predicted vote for each precinct is obtained.

Political affiliation and Proposition 207 voting

Although we did not include a political affiliation variable in our model of voting for Proposition 207, to avoid issues of circularity, we did explore the role of such affiliation through three secondary analyses. We anticipated that there would be a positive relationship between support for the Democratic party in the 2020 Presidential election and the vote in favor of Proposition 207. To test this, we regressed the MGWR intercept, which indicated intrinsic support for, or opposition to, Proposition 207 on the percentage of the vote for Biden (the Democratic Party candidate) in the 2020 presidential election. As anticipated, there was a significant positive relationship between the two votes, and the Pct Biden variable accounted for 28% of the variance in the Proposition 207 vote (Table 4). This suggests that part of the intrinsic contextual effect we measured from MGWR was related to political affiliation, but most was not.

In a further analysis (Table 5), we regressed the MGWR residuals on the Pct Biden voting variable to test the association between political affiliation and Proposition 207 support again. However, we found that the voting preference variable explained only 4% of the variance in the MGWR residuals. This may be a result of the circularity issue mentioned previously: since the independent variables used in the Proposition 207 model were also strong predictors of the Biden vote in the 2020 presidential election, the residuals, which were independent of the covariates in the model, had little relationship with the Biden vote.

TABLE 4 Regression of the MGWR local intercept estimates on the Pct Biden vote from the 2020 presidential election.

	Est.	SE	*t* value	*p*-Value
(Intercept)	−.3621	.046023	−7.868	7.07e−15***
Pct Biden	.019882	.000843	23.595	<2e−16***
R^2	.28			
Adj. R^2	.28			
p-value	2.2e−16			

***$p = .001$.

TABLE 5 Regression of the MGWR residuals on the Pct Biden vote in the 2020 presidential election.

	Est.	SE	*t* value	*p*-Value
(Intercept)	−.2249184	.0299138	−7.719	2.19e−14***
Pct Biden	.0039852	.0005335	7.47	1.39e−13***
R^2	.04			
Adj. R^2	.04			
p-value	1.387e−13			

***$p = .001$.

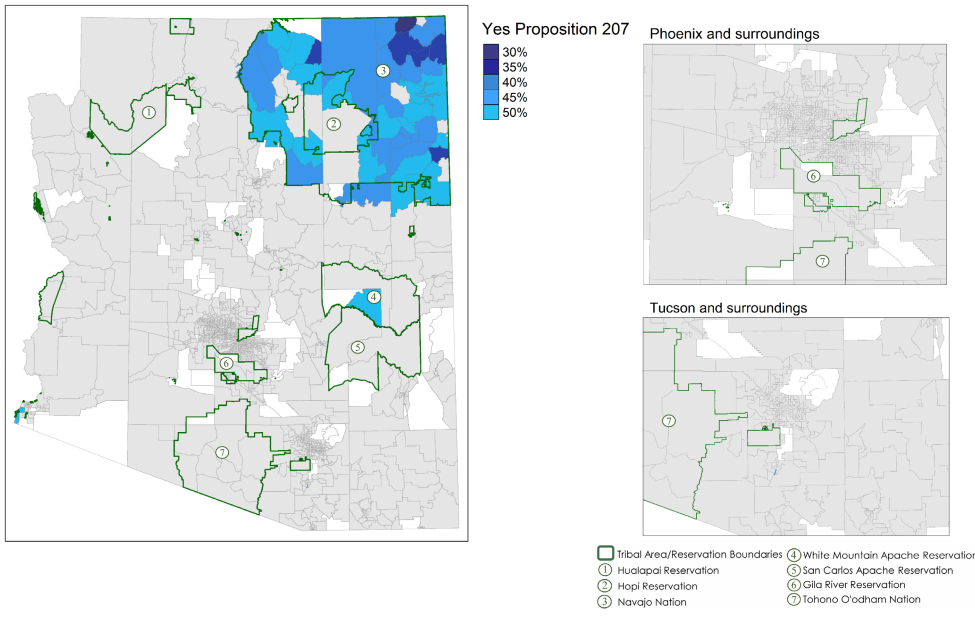

FIGURE 8 Voting preferences—Pct Biden ≥50.01% and Prop 207 yes ≤49.99%.

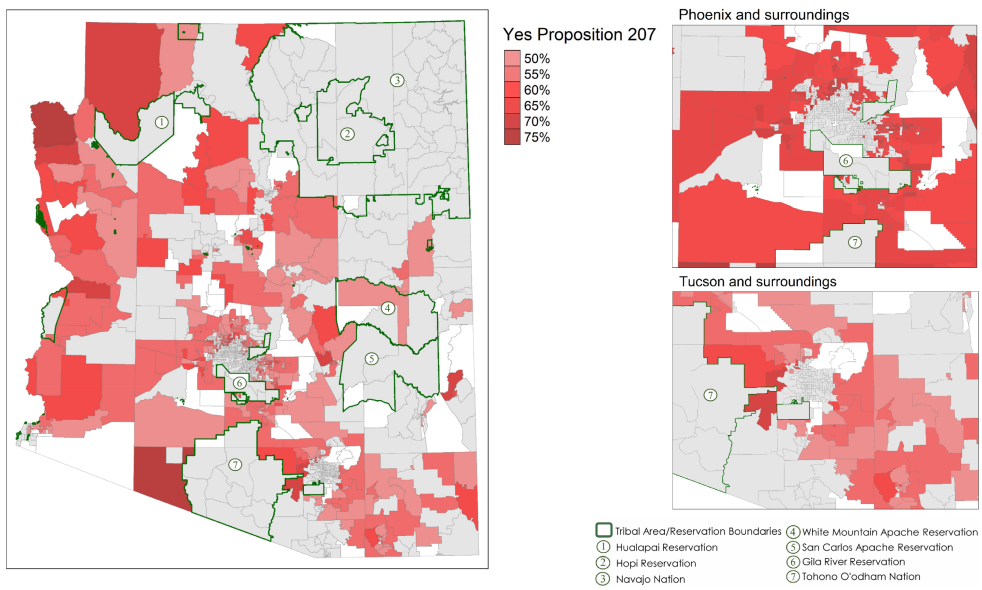

FIGURE 9 Voting preferences—Pct Trump ≥50.01% and Prop 207 yes ≥50.01%.

In a final analysis, we conducted simple Boolean mapping of the two sets of votes. We assumed that voters who supported the Democratic presidential candidate (Biden) in 2020 would also support Proposition 207, while those who voted for the Republican candidate (Trump) would oppose the measure. We used a Boolean approach to identify precincts in which these assumptions did not hold, the results of which are shown in Figures 8 and 9.

Figure 8 shows voting precincts in which Biden won (≥50.01%) and Proposition 207 *failed* (≤49.99%). Tribal areas in Arizona were strongholds of Democratic support during the 2020 election (Štroblová, 2021). Yet, Figure 8 reveals that, particularly within the Navajo Nation, support for Biden was not associated with support for Proposition 207. This map supports the MGWR parameter map findings that illustrate the relative lack of *local* support for Proposition 207 in Arizona's tribal areas (see Figure 5). This localized opposition to Proposition 207 does not register in a global model in part because it represented a small percentage of the Democratic vote. Of the 696 precincts in which Biden garnered ≥50.01% of the vote, only 44 (6.32%) voted against Proposition 207 (≤49.99%).

Figure 9 shows voting precincts in which Trump won (≥50.01%) and Proposition 207 *passed* (≥50.01%). These counterintuitive results may help explain the modest effect of the percent Biden variable on the MGWR intercept and residuals. This counterintuitive voting behavior occurred in far more precincts than we anticipated. Of the 676 precincts in which Trump garnered ≥50.01% of the vote, 528 (78.12%) also voted *in favor of* Proposition 207 (≥50.01%). This result counters the long-standing opposition of Republican voters to recreational marijuana legalization measured in many opinion polls (Brenan, 2020; Geiger, 2016; Schaeffer, 2021). However, this map does corroborate findings that support for marijuana legalization has been rising among people of *both* parties over time (Denham, 2019). This finding also fits within the ongoing recent trend of recreational marijuana legalization in states with conservative voting histories like Montana, Missouri, and Ohio. It may also help explain why similar ballot measures were proposed, albeit unsuccessfully, in states like Arkansas, North Dakota, and South Dakota. Figure 9 helps us further understand why the Pct Biden variable explains less of the variance in the MGWR local intercepts and residuals than anticipated.

Study limitations

We apply MGWR, the latest advance in local modeling that builds on and improves older, more established approaches, such as GWR, to the votes for Proposition 207 to legalize marijuana sales within Arizona. The results suggest strongly that it is important to look at the determinants of voting behavior locally rather than globally. However, certain caveats apply to this research. One is that because we have used fine-scale spatial data on voting (the precinct level), we had to use the dasymetric apportionment tools in ArcGIS Pro to geo-enrich voting precinct polygons with data on the covariates used in the model. If there were inaccuracies in how this algorithm apportioned data to the voting precincts, it could distort the findings from the analysis. It is also important to clarify that the ESRI Business Analyst geo-enrichment tool created demographic data for the entire population of the voting precincts. It did not provide voter registration demographics, which might produce better results but were unavailable for Arizona voting precincts.[21] When and if precinct-level demographic data for registered voters are collected and made available, the analyses we provide here can be further improved. Analyzing the vote on Proposition 207 at the next spatial level where census data were readily available, the county, was not a feasible option. Arizona has only 15 counties, so local modeling at this scale is useless.

A second caveat is that we cannot be certain that we have incorporated all the necessary covariates in our model. However, we used covariates that other studies of marijuana legalization voting used, and we did investigate other possible covariates that proved to be of little or no use in explaining variations in the Proposition 207 vote across the precincts.

[21]This is particularly true for variables like median household income.

We return to the possibility of including a political affiliation variable in the analysis, but this would not produce any causal relationship: voters did not vote for Proposition 207 because they voted for the Democratic party in the 2020 presidential election—they voted for Proposition 207 and the Democratic party because they had certain demographic profiles. Therefore, the inclusion of a political affiliation variable would have introduced a great deal of circularity into the model on voting for Proposition 207, which would have led to severe misspecification biases being introduced into the parameter estimates obtained in both the global and local models.

DISCUSSION

The legalization of recreational marijuana is an ongoing trend in the United States. By November 2023, 24 states and Washington, D.C., had passed legislative bills or ballot measures to legalize recreational marijuana. In 2020, Arizonans voted to legalize recreational marijuana by approving Proposition 207. While previous scholars have used global statistical models to understand support for recreational marijuana legalization, this research shows how MGWR, a local modeling approach, can provide a much more nuanced analysis of ballot measure voting behavior.

First, our results indicate that several predictors used in previous research regarding recreational marijuana ballot measure voting behavior were also useful to understand voting behavior in Arizona. A number of the same trends emerged in Arizona. For example, higher median household incomes and age brackets (65+) continued to be associated with opposition to marijuana legalization. Higher population density, education, and concentrations of particular race/ethnic groups continued to be associated with support for marijuana legalization.

However, the MGWR analysis reveals that these variables behaved differently according to location. While some covariates, such as the proportion of elderly voters within a precinct, had a relatively consistent impact on voting in favor of legalizing marijuana, others, such as the percentages of Hispanic and Native American voters within a precinct, had impacts that varied regionally or locally. These findings are an important starting point for additional research efforts designed to better understand why voting precincts with certain characteristics supported marijuana legalization while others opposed it. These nuanced behaviors are overlooked in previous ballot measure studies using global measures.

In addition to a better understanding of covariate effects on ballot measure voting, MGWR provides a means of separating and quantifying the impacts of geographical context and sociodemographic composition on ballot measure voting behavior. These analyses can be used to test further if (and how) previous findings from global models vary locally. In this analysis, the sociodemographic impact on voting confirmed results from previous research showing opposition to marijuana legalization in rural areas and support for legalization in urban areas. However, the analysis also revealed that in much of Arizona, there was support for, or opposition to, marijuana legalization associated with geographic context. This means that there were unmeasured or unmeasurable characteristics of places throughout Arizona that led to support for, or opposition to, marijuana legalization. By revealing where and to what degree geographic context contributes to voting outcomes, MGWR informs us where local knowledge could explain how context shapes voting behaviors.

If indeed, as Tip O'Neill suggested, "all politics is [*sic*] local," spatial analyses of ballot measure voting should account for *local* variations in voting behavior. By using MGWR, we can test which variables best explain voting behavior and *where* their capacity to explain behavior varies. Findings from MGWR analyses may have value for businesses, government agencies, and other groups that need to understand how the costs and benefits of recreational marijuana

legalization, and other policies established via ballot measures, are distributed. A better understanding of the local landscape of voting behaviors can help inform the implementation of ballot measure policies. In this analysis, statistically significant MGWR intercept areas illustrate areas of intrinsic support for or opposition to Proposition 207. Areas with higher intrinsic support may be better for the location of marijuana growing and sales facilities in Arizona than those with intrinsic opposition to the ballot measure. Analyses that reveal intrinsic support for, and opposition to, ballot measures can help us understand if the local ordinances enacted to restrict ballot measure implementation reflect the will of the voters in those areas. If used correctly, MGWR can be a powerful tool to help understand much broader aspects of ballot measure voting behaviors, which are such vital components of direct democracy processes in the United States and around the world.

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ORCID

Mason Clay Mathews https://orcid.org/0000-0002-9695-5316

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AUTHOR BIOGRAPHIES

Mason Clay Mathews is an Assistant Research Professor at the Knowledge Exchange for Resilience in the School of Geographical Sciences and Urban Planning at Arizona State University. His research interests include spatial and relational topics, such as those related to the impacts of geographic space on social capital. He is the author of research such as "How Village Leaders in Rural Amazonia Create Bonding, Bridging, and Linking Social Capital Configurations to Achieve Development Goals, and Why They Are So Difficult to Maintain over Time," *World Development* (10.1016/j.worlddev.2021.105541).

A. Stewart Fotheringham is Regents' Professor of Computational Spatial Science in the School of Geographical Sciences and Urban Planning at Arizona State University where he is also Director of the Spatial Analysis Research Center (SPARC). He is a member of the U.S. National Academy of Sciences and of Academia Europaea and a Fellow of the UK's Academy of Social Sciences and of the American Association of Geographers. His research interests are in the analysis of spatial data sets using statistical, mathematical and computational methods. He is a co-author of a recent book entitled *Multiscale Geographically Weighed Regression: Theory and Practice*, published by Routledge (CRC Press).

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