The Economic Effects of American Slavery: Tests at the Border*

March 21, 2022

Version 32

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Abstract: To engage with the large literature on the economic effects of slavery, we use antebellum census data to test for statistical differences at the 1860 free-slave border. We find evidence of lower population density, less intensive land use, and lower land values on the slave side. This does not support the view that abolition was a costly constraint for landowners. Indeed, the lower demand for similar, yet cheaper, land presents a different puzzle: why wouldn't the yeomen farmers cross the border to fill up empty land in slave states, as was happening in the free states of the Old Northwest? On this point, we find evidence of higher wages on the slave side, indicating an aversion of free labor to working in a slave society. This evidence of systemically lower economic performance in slave areas suggests that the earlier literature on the profitability of plantations was misplaced, or at least incomplete.

* Preliminary and incomplete. Comments welcome. For excellent research assistance, we thank Michael Finegan. For helpful comments, we thank Marcella Alsan, Jeremy Atack, Vellore Arthi, George Alter, Brian Beach, Dan Bogart, John Bound, Charles Brown, Gregory Clark, John Clegg, Bill Collins, Lisa Cook, David Donaldson, Price Fishback, Martin Fiszbein, Edward Glazer, Timothy Guinnane, Joshua Hausman, Eric Hilt, D. Rod Kiewiet, Naomi Lamoreaux, Peter Lindert, Trevon Logan, John Majewski, Robert Margo, Michael Mueller-Smith, Aldo Musacchio, James Oberly, Alan Olmstead, Sarah Quincy, Ana Reynoso, Stephen Redding, Gary Richardson, Elyce Rotella, Vasily Rusanov, Yannay Spitzer, Matthew Spooner, Melvin Stephens, Peter Temin, Virginia Traweek, Marlous van Waijenburg Marianne Wanamaker, Warren Whatley, Gavin Wright, and Ariel Zimran, as well as participants at presentations at Michigan, Harvard, UC Davis, UC Irvine, Vanderbilt, Yale, and the Cliometrics conference, the Economic History Association annual meetings, and the Social Science History Association conference.

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I. Introduction

Social scientists have long sought to understand the effects of slavery on economic growth and development. Alexis de Tocqueville and Gustave de Beaumont, for example, wrestled with the issue during in their famous visit to America in 1831-32. While in the Northeast, the French visitors heard much about the distinctiveness of the American South, but they felt unable to sort out the impacts of slavery from those of climate and soil. When they traveled to the Ohio River valley, they discovered a setting where the environment was the same on both sides of the river; but the institutions differed.[1] They observed that free state of Ohio was more dynamic, more industrious, and more attractive to immigrants, than the slave state of Kentucky. De Tocqueville wrote: "It is impossible to attribute those differences to any other cause than slavery. It brutalizes the black population and debilitates the white…. Man is not made for servitude. (Pierson 1938, p. 569)."

Over the next century, historians largely echoed the conclusion that slavery harmed economic performance. They argued that slavery was unprofitable and was kept in place by an elite who sought to maintain their political and social hegemony (see Aitken 1971). In the mid-twentieth century, economic historians brought to bear quantitative evidence that seemed to challenge this view. They argued that plantations were profit-maximizing businesses and slavery was a dynamic economic form, far from dying out due of unprofitability (Conrad and Meyer 1958, Fogel and Engerman 1974). In the last two decades, economic historians and others have advanced a more nuanced position that slavery in the Americas had an economic rationale early on but created institutional impediments to subsequent growth (Engerman and Sokoloff 2011). Places with coercive labor in the 1800s appear to have started modern economic growth later and have worse development experiences today than places with free labor. This was becoming the standard view. But, more recently, the "1619 Project" of the *New York Times Magazine* (2019) has popularized the New History of Capitalism, which founds US economic success directly on slavery (Beckert 2015). The core issues remain contested.

In this paper, we return to an investigation of the impact of slavery on economic performance during its existence. To proceed in a controlled yet tractable way, we examine the effects of the peculiar institution at the border that divided the country in half, slave and free, circa 1860. Following in the footsteps of de Tocqueville and de Beaumont, we seek a testing ground

[1] See Yale Tocqueville Manuscripts. American Trip, Diary and Notes, Cashier E. DeTocqueville's words read: "Il est impossible d'attribuer ces differences a una autre cause que a il esclavage. Il abrusit la population noire et inerve [sic] la population Blanche….l'homme n'est pas fait pour la servitude." See also Zunz (2010, pp. 180-81).
By the 1830s, local observers had made frequent contrasts between the development patterns on the two sides of the river. See *Edwardville* (IL) *Spectator*, 1 May 1821, p. 3.

where the environmental differences do not confound the comparisons. Much of economics literature on slavery conducted tests for whether marginal benefits of something equal its marginal cost at the farm level: roughly speaking, tests of productive efficiency and profit maximization. We argue that these are the wrong questions for assessing the economic effects of the institution. If a slave-based firm was unprofitable, one would expect it to go out of business, leaving fewer in operation. Instead, we propose a different perspective: the policy variable on either side of the free-slave border should affects how those free-to-choose could use their land. Abolition may act like a large tax on slavery in local areas. Local public economics teaches us that the inelastic factor bears such taxes (Tiebout 1958). Physical capital is mobile, free labor is mobile, and slave labor is mobile, even if not by the will of the enslaved. Land, in contrast, is immobile. If we wish to measure the systemic productivity of a local or regional policy, we should therefore direct our attention to land use and price.[2]

On the one hand, the institution of slavery created different set of production possibilities. It allowed labor to be coerced, which should have lowered the cost of labor to the slave owner. The institution of slavery also facilitated the attainment of greater scale. More generally, the ability to enslave others generated profit opportunities for the enslavers; sites where profitable activities were legal should, all other things equal, be more valuable than sites where such activities are not legal.

On the other hand, the institution of slavery was a social system that oppressed and degraded the enslaved. In doing so, the system also levied taxes on and inhibited the activities of the non-slave-holders. Complicity with the violent system imposed costs that some free people might seek to avoid. Slavery had existed in many parts of the world for millennia. In many places, including the US South, the use of coerced labor was so importance as to shape the region's institutional core, creating not just a society with slaves, but what Moses Finley (1980) and Ira Berlin (1998) call a "slave society." The US North prided itself on being a place where slavery was not permitted and "free labor" was celebrated (Foner 1970; Lincoln as quoted in Basker 1953, pp. 471-82). This was a choice.

This paper seeks to measure the relative strengths of these opposing forces affecting the use and value of land in areas with and without slavery. We take the testing ground of de Tocqueville and de Beaumont -- the Ohio River valley-- and extend the comparison east to cover the borders dividing Pennsylvania and New Jersey from Virginia, Maryland and Delaware and west to contrast free states of Illinois and Iowa with the slave state of Missouri (de Tocqueville 1838, Chase and Sanborn 1856, Thomas and Ayers 2003, Wright 2006). The border was the divided line between slavery and free labor institutions within the same country, with a common language, national laws,

[2] Land prices also have the virtue of being comparable across regions. See Appendix A for model of the effect of labor scarcity on land values.

and shared heritage.[3] We use antebellum census data to test for statistical differences, as captured by a coefficient on the legality of slavery, at the 1860 free-slave border.[4] We find evidence (in Section V) of less intensive land use and lower land value on the slave side of this border. This does not support the view that abolition was a costly constraint for landowners.

Indeed, the lower use of land that was cheaper presents a prima facie puzzle: why wouldn't the yeomen farmers cross the border to fill up "empty" land in slave states, in the same ways they did in the free states of the Old Northwest? More puzzling still is that we find evidence (in Section VIII) of higher wages on the slave side of the border. We then turn to interpret the results in a variant of the Rosen-Roback locational choice model (Roback 1982). The combination of lower land rents and higher wages would indicate that there was a large disamenity for free households to live and work in the slave region. In Section IX, we seek to account the farm-value difference. Farm improvements --relative levels on investment in farm buildings and land clearing-- explain a meaningful fraction of the gap; the differences in wages explain much or most of what remains. Differences in agricultural total factor productivity appears to explain only a small fraction of the gap, while differences in pecuniary taxes work in the opposite direction. Furthermore, the estimated reduction in land wealth in the slave side of the border region was of the same magnitude as the slave wealth held there, which suggests that the institutional structure sustaining slavery was itself hindering the region's economic performance.

We are treating the two sides of the border as competing for settlement and economic activity. They are not separate testing grounds, but rather interact and compete. Some spillovers such as the prospect for the enslaved to escape complicate the contrast and we seek to control for these effects by also looking off the immediate border. It is important to notice that in addition to sharing similar climate and soils, the two sides of the river face similar product prices. There are no internal duties on physical commodities and transportation costs to global markets are the same. Many of the border segments were on navigable waterways, making differences in investments in internal improvements less immediately salient. These differences, which deserve the attention that they have received in the literature (Majewski 2000), matter less in these border segments. An obvious concern is whether differences observed in the border region extend to the broader slave-free comparison. Our analysis indicates that they do, and if anything, many differences become more pronounced as the geographic scope of our investigation widens.

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[3] The recent economic literature includes many studies making border comparisons (Dell 2010, Acemoglu and Robinson 2012). The border considered here lies at the heart of the main issue in early US history, the competition and co-existence of the slave and free labor systems within the same nation-state.

[4] The main data that we use were collected during the period of study under a common statistical authority; they are relatively abundant, but of course do not address every question of interest. Our tests of the "slavery effect" are based on the legality of slavery circa 1860; they differ from tests in the existing literature of the relationship, within the slave region, between various outcomes and the slave share of the total population. We thank Gavin Wright for highlighting this contrast.

II. The Legal Basis of the Institutional Differences

Allowing for slavery was the default condition of the North American colonies. Colonists petitioned at various points to ban further importation of slaves, but royal representatives denied them. Georgia restricted the institution at its founding in 1732 but by 1750 revised its laws to permit slave holding. Following the start of the War of Independence, the Northern states began to eliminate the slave system and emancipate those held in bondage. Pennsylvania was a leader, passing the "Act for the Gradual Abolution of Slavery" on 1 March 1780. The 1787 Northwest Ordinance, passed by the US Congress during the Articles of Confederation period, forbad slavery in the territory north of the Ohio River. The Sixth Article read "There shall be neither slavery nor involuntary servitude in the said territory, otherwise than in punishment of crimes whereof the party shall have been duly convicted." This law was contested at times and laborers in the region were sometimes bound under indentured servitude contracts. But the founding document of the Northwest Territory prohibited chattel slavery. South of the river, in Kentucky, the legal system adopted Virginia practices; chattel slavery was in place when Kentucky became a state in 1792. In 1820, Missouri was also admitted to the union as a slave state, as part of a compromise excluding slavery in the other parts of the territory of the Louisiana Purchase above the longitude 36 degrees 30 minutes (Wright 2006, pp. 44-46; Simeone 2000).

Readers who question our framing might be persuaded by the words of Honest Abe Lincoln. On his speaking tour through Ohio and Indiana in September 1859, Lincoln repeatedly attributed that the absence of chattel slavery in the states formed from the Northwest territory to 1787 Ordinance and to the refusal of Congress to allow early legislatures to backtrack on the provisions of Article VI. "There is no difference in soil nor in climate" along the border, Lincoln noted, but the different institutional choices at founding led to different outcomes.[5] Relatedly, Lincoln's argument against 'popular sovereignty' included a notion of path dependence: once slave owners were present in a territory, it created a constituency seeking to preserve and expand the peculiar institution.

We compare the operation of slavery and free labor in a classic testing ground (de Tocqueville 1838, Wright 2006).[6] This region includes the core domain of slavery in the country's early history. Slave labor was commonly used to produce the region's staple crops. And there were

[5] Speeches at Indianapolis, IN, 19 Sept. 1859 and at Cincinnati, OH, 17 Sept. 1859 in Basker (1953, pp. 456-57, 467).

[6] An additional reason to examine the border region is its importance. It was hardly a marginal area. In 1860, over one half (52.1 percent) of the total population of the free states lived within the 150-mile band. Almost four-tenths (38.6 percent) of the population of the slave states did so. For the country as a whole, almost one-half (46.8) did so. The 300-mile band covered 91.4 percent of the population of the free states, 67.8 percent of the slave states, and 82.2 percent of the total. Nearly 900 (898k) thousand enslaved African-Americans, 23 percent of the total number of slaves, lived within the 150-mile band. Over 2 million (2098k), or 53 percent of the total, lived within the 300-mile band. The shares of slave-holding households were even higher; 34 percent lived within the 150 mile-band and 64 percent within the 300-mile band. See also Smith (1927, pp. 2-3).

repeated attempts, during crop booms, to introduce slavery into the places where it was legally prohibited in the founding period. These attempts failed, but many voters in the Free States were not convinced that nature alone would forever keep slavery out. The contest went the other way as well. By 1860, slavery had almost completely disappeared in New Jersey; it was on the decline in Delaware; other parts of the border South might be next. The border test has relevance for how US history played out and how the participants saw it playing out.[7]

III. The Free-Slave Boundary and Census Data

Figure 1, Panel A, maps the Free-Slave Boundary in the United States in 1860 and the surrounding regions (see Appendix B for details).[8] The thick line is the boundary and the thin lines are 1860 state borders, plus the subsequent border that split the two Virginias. We will investigate the effects of slavery using the abundant county-level data from the antebellum censuses: population, by demographic type, land value, land use, crop mix, farm size, and other variables of interest.

We offer two leading examples in the remaining panels of Figure 1: Panel B represents non-white population (mainly blacks) and Panel C represents the rural population. Each dot is placed at the county centroid and is proportional to the percentile of the respective outcome.[9] The propensity of nonwhites to be south of the boundary is noteworthy, while the rural population is far denser in free states. A few other features are evident in the maps: the relative emptiness of Appalachia and the settlement along the Missouri River, for example.

Table 1 provides summary statistics for some of the data in our sample. In Panels A and B, respectively, we consider two samples: counties with centroids within 300 miles of the border and counties on the border. The columns present numbers of observations, means, and standard deviations, for the entirety of each sample as well as for free-region and slave-region subsamples. There are three variables for population: nonwhite, white, and rural, all normalized by county area. There are 5.3 (4.2) nonwhites per thousand acres in the first (second) sample. However, there is a much greater density of nonwhites south of the boundary, with an additional 8.7 (5.0) per thousand acres on the slave side. In each of the subsamples, white population density is higher north of the border: there are 43.9 (21.3) more whites per thousand acres on the free side. A similar pattern

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[7] The data that we are examining come from the 1850s. This is a period when the slave system is thriving. The price of an average slave rose from $377 in 1850 to $778 in 1860. (Ransom and Sutch 1988, Table A1.) The market for raw cotton is booming. In contrast to the first half of the nineteenth century, the tobacco market is doing well in the 1850s.

[8] The source for the spatial data is the National Historical Geographic Information System (NHGIS, Minnesota Population Center, 2011). Population data are from census counts compiled in ICPSR study No. 2896 (Haines 2010). The agricultural data are census statistics compiled in ICPSR study No. 35206 (Haines, Fishback, Rhode 2018).

[9] We use percentiles to make the graph legible. The statistical analysis below is based on levels and natural logarithms.

holds for rural population: more nonwhites on the slave side; and more whites on the free side. The offset is not one-for-one; the combined population density is much higher on the free side.

There are four agricultural outcomes of immediate interest. About 60 percent of acres were in farms, on average, and these numbers are fairly similar across samples on both sides of the border. A large gap is seen in land improvement, however, across the free and slave counties. Finally, we present farm values per county and also per farm acre. At the border, farms are valued at about $24 per farm acre, but there is an over $8 difference on either side. Measured in logs, the farm acres on the slave side are approximately 37 percent less valuable.

Moving to our more formal econometric tests, we employ the following estimation procedures. We focus on four samples: those counties that touch the border (the border sample), those that are near the border but do not touch it (the donut sample), those that are within 150 miles of the border, and those that are within 300 miles.[10] We run one of two specifications:

(1) $Y_i = \beta_1 * Slavery\_Legal_i + \gamma_1 * Longitude_i + \gamma_2 * Longitude_i^2 + \gamma_3 * Longitude_i^3 + \gamma_4 * Distance_i + \gamma_5 * Distance_i^2 + \gamma_6 * Distance_i^3 + \beta_0 + \varepsilon_i$

(2) $Y_i = \beta_1 * Slavery\_Legal_i + \gamma_1 * Longitude_i + \gamma_2 * Longitude_i^2 + \gamma_3 * Longitude_i^3 + \beta_0 + \varepsilon_i$

All of these specifications include controls for a cubic in longitude. For the 150- and 300-mile buffers, we run specification (1) which also includes controls for a cubic in distance to the boundary, which is defined as a positive to the North in a negative to the South. For the border county and donut samples, distance to the boundary is nearly collinear with free or slave. For these samples, we run specification (2) excluding the distance controls. This analysis is weighted by county area so as to not inflate the importance of states that subdivide more than others. To account for spatial correlation, we cluster by 15 bins of longitude.[11] The coefficient of interest is on an indicator for whether slavery is legal. Generally speaking, the slave region is south of the boundary.

Figure 2 provides evidence on environmental variables, e.g. weather and soil, which are--for the most part--pre-determined. This helps us assess the strength of our research design that compares area on either side of the border. Panel A contains results in the areas of weather,

[10] The distances are measured from the county centroid.   See Appendix Figure B-1 for a map of the buffers and the border sample in 1860. The donut sample is not on the boundary directly, but within 55 miles of it. The 55-mile cutoff is approximately double the maximum average distance to the boundary in the border sample and it ensures that there is at least one county on either side. We created the donut sample to address two concerns about a comparison right at the border: (1) slave owners fear enslaved workers might escape, and (2) opportunities for trade, especially on navigable rivers, might mute the effects of institutions on land use.

[11] We select this clustering method based on an analysis of the spatial correlation across bins. Smaller bins of longitude (e.g. 30 evenly sized groups instead) show statistically significant residual correlation across adjacent bins. We use Moran's I statistic to diagnose spatial correlation, as suggested by Kelly (2020). We also implement Kelly's and Conley's, (1999) proposed estimators in sensitivity analysis below.

topography, river/water access, and seismology. Panel B represents tests for soil-related variables, including the glacial coverage (which is described in Appendix C). Some rows have numerous coefficients because the categories (listed on the y axis) are measured at various soil depths. We plot the p-value on the slavery coefficient for each variable and sample. A uniform distribution across [0,1] would imply no meaningful differences across the border. A departure from uniform indicates otherwise, with caveat that the coefficients are not independent draws (e.g. sandy soil 10 inches down is correlated with sand fraction at 15 inches). Panel A has 10 of 52 (19 percent) coefficients significant at the 10 percent level. Outside of the climate variables, 4 of 36 p-values are below 10 percent, and none are below five percent. There are not significant differences in elevation on either side of the river. The climate should also be quite similar on either side of these borders. Much of the boundary line is defined by a river that runs through flat terrain, so there are not issues of rain shadows from mountains.[12] Our review of the river course indicates that the bends on the river are evenly distributed. There is local heterogeneity but this averages out over the river course. The rest of the boundary is defined by geometric constructs (east/west lines and the Twelve-Mile Circle) that were set well before much was known about land quality. Nevertheless, the story is bit more complicated in Panel B, where 29 percent of coefficients have p-values before 10 percent. A few outcomes look reasonably uniform, e.g. porosity or bulk density. Several look uniform for some samples, but not others: for example, soil pH, which looks uniform for the buffer sample, but bad for the donut sample. Glacial extent (meaning fraction of the county covered by ice at the previous glacial maximum) and depth to bedrock are most significantly related to the free-slave boundary. All of the above controls will be used in the sensitivity analysis below.

IV: Demographics

Figure 3 graphs the point estimates and 95-percent confidence intervals for key demographics attributes in 1860 for the four samples. The top set of results represents the principal attribute, non-whites as a share of the population. These results demonstrate the non-white share was indeed higher in the slave region. Given that non-white people were more likely to be subject to labor coercion, finding this difference is something like a first-stage regression for our analysis.

Examining additional results, we observe the ratio of non-white population to total land area is higher in the slave region. But the white population per land area is lower, and total population density is lower. This gap is not due solely to differences in urbanization. Total rural population per land area is substantially lower – by about one-half– on the slave side. If we examine

[12] For temperature and rainfall, the standard errors of the kriging (interpolation) exercise are somewhat more related to free-slave region than are the interpolated climate variables themselves. This indicates that these effects come in part from the endogenous placement of weather stations rather than real differences in climate. Note that the climate data come from the mid-nineteenth century and are described in Bleakley and Hong (2017). We eschewed modern climate raster data because (endogenous) urban heat islands are clearly visible.

regressions using natural units rather than logs, we observe the slave side is associated with, per thousand acres, 6 more nonwhites and with 40 fewer whites. This defies the simple story that enslaved laborers and artisans displaced free workers at specific tasks, for which one might have expected estimates closer to parity. On the slave side, the mean densities are about 16 for nonwhites and 61 for whites per thousand acres, so these are large effects.[13]

For all the variables, the point estimates for border and 150-mile samples are very close to each other. Those for 300-mile sample shows larger gaps, a finding explored in Section IV: E below.[14] A parallel analysis of population attributes in 1850 would yield very similar results. The lower density speaks to land use; a given land area in the slave region was devoted to supporting far fewer people.

V. Land Use and Value

Figure 4 presents results on the effect of slavery on farmland use and values. As noted in the introduction, the local public finance literature considers such variables to be sufficient statistics for evaluating the economic effects of local institutions and policies affecting property rights. (Such a calculation does *not* account for equity issues, which are very significant in this case.)

We start with farmland use in 1860. The share of farmland in total land is smaller in the slave region, but just barely so. The differences are not statistically significant. The share of improved farm acreage in total land is lower, and, for both the donut and border samples, the differences are statistically significant. Parsing these two findings, we see the share of improved acres in farm acreage is lower in slave region. The differences are now all statistically significant at the 95-percent level. In summary, farmland was used far less intensively on the slave side.

Differences also appear in farm values. Farm values per capita are lower in the slave region, but the gaps are not so large as to be significantly different from zero. We then shift from dividing the value of farms by population to dividing by county land area. Here the gaps are large and statistically significantly different from zero. Then we divide instead by farm acres. Farm values per farm acre are substantially lower in the slave region. The gaps are economically huge, a

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[13] See Table 2, Panel C. The use of levels instead of logs also facilitates the analysis of slave population, which is zero in many of the counties. If we put enslaved population density on the left-hand side, we obtain a coefficient of 5.5 more slaves per thousand acres. This is very close to the estimate for nonwhite population.

[14] Appendix Figures F-3 and F-4 extend the analysis to cover differences in the age composition of the 1860 population and in sex, race, and nativity, respectively. Appendix Figure F-3 shows the slave region had relatively more young people (10-14 years) and fewer older people (40-79 years). This pattern is in line with the characterization of the border South as an area where young slaves were raised to be sold “down river.” The magnitudes of the differences, however, were not great. Appendix Figure F-4 shows more non-whites in the slave region, more males and more females. But again, the gender differences were not great. There were fewer free people of color and, marginally, fewer foreign-born whites. The evidence of lower fraction of foreign-born is weaker that one might expect given the common narrative that immigrants strictly avoided slavery. There appears to be little difference from the behavior of native-born whites.

reduction on the order of 55 percent.[15] In natural units, the reduction in farm value is about $8 per county acre or $11 per farm acre. (Furthermore, approximately 13 percentage points less of total farm acreage is improved on the slave side.) An analysis of farmland use and values in 1850 yields similar results.

In summary, farm values per farm acre were substantially lower – by over one-half–in the slave region. The ratio of improved land to farm acre was also lower.[16] These findings are puzzling for the models in which coercion made labor cheaper, which would have raised land rents. The puzzle extends to models where the legal capacity to engage in activities-of-value (such as raising slaves for sale) increases land values. At the strictly micro-level, producers had access to more modes of production south of the border. Yet there was lower demand for that land.

VI: Sensitivity Analysis

Results, reported in Tables 2, 3, and 4, should assuage reader's concerns about omitted variables, endogeneity, geospatial correlation, and external validity. The estimates are qualitatively similar under a variety of alternate assumptions. The time-pressured reader might wish to skip ahead, though the results on external validity (Section VI.E) merit special attention. That analysis shows the patterns observed extend far beyond the border comparison.

VI.A: Additional Variables

In Table 2, we present estimates of the effect being in the slave region on the main outcomes, in the full sample. In the first row of Panel A, we see the baseline results, which use land area as a weight in the regression. In the next two rows, we find broadly similar results if we weight by rural population or use no weights at all.[17] The final row of Panel A assigns the few observations with a zero or missing value for the outcome to the sample minimum value instead. This has its greatest effect on the sample size of the nonwhite population, as there were a comparatively large number of counties that were 100 percent white in the 1860 census. In any case, this adjustment does not affect the estimates to a great degree.

Panel B of Table 2 presents estimates using a variety of spatial controls. In the first three rows, we include dummy variables based on splitting the sample into five, ten, and then fifteen bins of longitude. The fourth row includes instead a cubic polynomial in latitude and longitude, which is

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[15] Appendix Figure F-2 performs a parallel analysis of the z-scores associated with farmland use and value in 1860. The finding that farm value per acre was lower in the slave region again is apparent.

[16] One notable outcome comes from contrasting the third and sixth sets in Figure 4. The third set shows the fraction of farmland that was improved was lower in the slave region whereas the sixth set shows farmland values were lower. The point estimates in the third set of results are smaller than those in the sixth, so the farm value gaps are not explained mechanically by the gap in improved acreage in 1860. Similar results hold in 1850. See also Section IX:A below.

[17] Neither of these was the preferred specification because the former is endogenous to county land quality and institutions and the latter gives more weight to states, e.g. Kentucky, with greater proclivities to subdivide themselves.

distinct from the default specification based on longitude and distance from the free-slave border. Results including these purely spatial controls do not deviate substantially from the baseline. The next five rows show results controlling for the environmental factors. These variables were described already in reference to Figure 2, and most were not significant predictors of being on the free side of the boundary. The first row in this batch contains variables for topography, river access, groundwater, and climate. The second row controls for depth to bedrock, which is correlated in a statistically significant way with the institution of slavery, but whose inclusion in the model does not affect estimates associated with the free-slave boundary. The next row includes instead the remaining soil measurements described above. Results are generally similar, although there is now a statistically significant effect of slavery on farm acreage per county area and the estimated effect of slavery on farm value per county area is somewhat lower than the baseline. The next two rows control for the fraction of the county covered by the most recent glacier. The second row of this pair leaves out the Driftless region, mostly within southwest Wisconsin, and is therefore simply a measure of being north of the terminal moraine. These estimates are comparable to the baseline.

Panel C, Table 2 presents results for the standard outcomes, but defined in levels rather than in natural logarithms. These estimates differ because of the change of units, but the patterns of statistical significance are largely unchanged.

We now consider the possible confounding influence of land surveys. Notably, most of the Old Northwest was brought into the Public Land Survey System (PLSS), while much of the rest of the sample used non-rectangular, mostly metes and bounds, surveys for the demarcation of property (see Appendix D). Attention to this issue is motivated by three factors. First, the PLSS may affect transaction costs: perhaps reducing them, as argued by Libecap and Leuck (2011), or perhaps increasing them if the grid is set too far away from the optimal farm size, as argued by Bleakley and Ferrie (2014). Second, the Northwest Ordinance's demarcation scheme was in part motivated by a 'Jeffersonian dream' of yeoman farming (Gates 1996). Third, the use of the PLSS has said to induce more orderly, compact settlement, in contrast to a squatter-led regime.

The final row of Panel B reports results that directly control for the fraction of each county covered by the PLSS. Estimates are qualitatively similar to those with other specifications. We also split the sample based on whether the closest free-slave boundary is associated with the change in land demarcation system (specifically, PLSS versus something else). Most of the Ohio River, for example, is associated with a change, with the main exceptions near Cincinnati and Louisville. The Mason-Dixon line is not associated with a change, nor is most of the Missouri border, with the exception of riverside land near St. Louis that is associated with colonial French land claims. The first two rows of Table 3, Panel A, display these subsample estimates. Coefficients are remarkably similar, with the exception that the effect size is almost halved for fraction improved of farm acreage.

VI.B: Subsamples

Table 3 presents results for select subsamples, an exercise which is informative for its own sake and sheds light on the possibility of certain alternative hypotheses and mechanisms. Panel A splits the sample based on characteristics at the closest segment of the free-slave boundary. The role of different land surveys, analyzed in the first two rows of Panel A, was discussed above. The next three rows split the sample into three, less heterogeneous chunks of boundary: the Mason-Dixon line (plus northern and eastern borders of Delaware), the Ohio River, and the state of Missouri. Estimates are qualitatively similar across segments.

Next, we stratify based on whether the boundary is defined by a natural feature (in our case, rivers) or an artificial, geometric construct --the Missouri/Iowa border, the Mason-Dixon line, and the arc of the northern border of Delaware.[18] Both choices are arbitrary in some sense, and often selected historically based on imperfect knowledge of what is on either side. In any case, estimates across these two subsamples are broadly similar.

We next turn to heterogeneity of this effect by the timing of settlement along the boundary. We already have seen similar effects across three different, contiguous border segments, which were settled at different points in time. The last two rows of Panel A do something similar by splitting the sample by whether the closest boundary is east or west of the confluence between the Miami and Ohio Rivers (at the Indiana/Ohio state boundary). Then, in Panel B, we use the Newberry (2010) data on historical county boundaries to approximate the timing of settlement. The first two rows discriminate by whether the county's FIPS code first appears before the median year in the sample; the second pair of rows split the sample based on the emergence of the current county boundaries.

Another important consideration is soil exhaustion. Planters, it was commonly asserted, were irresponsible stewards of the soil (Craven 1926, Majewski 2016). A number of reasons were given: plantation crops were hard on the soil, the planters' ability to coerce the migration of their slaves gave little incentive to conserve the soil on their existing farm, principal/agent problems on large farms, etc. If true, this could explain the lower farm values on the slave side. It might also explain lower land improvement, if previously tilled acreage was abandoned and reclaimed by nature. We should first note that this claim is not consistent with the evidence just presented. Generally, coefficient estimates are similar across the previous three sets of sample splits, even

[18] The main natural rivers, the Ohio and Mississippi, provided ready transportation to both regions. Many of the smaller rivers saw active batteaux and flatboat traffic. Investments in other types of transportation improvements—river clearing, wing dams & sluices, roads, canals, railroads—are best viewed as endogenous outcomes in the development process. See Zimran (2020).

though the timing of settlement would have been quite different. Furthermore, in two of the three splits, the effects on farm value are weaker for counties settled earlier, even though those would have had more time to ruin their soil. We can also use a direct measure of the soil's susceptibility to erosion: the kf-factor, which measures the "susceptibility of soil particles to detachment and movement by water," and the k-factor, which is the same measure but adjusted for the presence of rocks. (Miller and White 1998). In Panel C, we display results for subsamples with larger or smaller values of these factors. The effect of being in the slave region on nonwhite population density is quite similar across the subsamples. However, we see discrepant results for most of the other outcomes. Nevertheless, these discrepancies do not favor the soil-exhaustion claim; for example, the effect on farm value is greater in places *less* susceptible to erosion. The skeptical reader might now observe that the soil variables are based on 20th-century surveys, and that the susceptibility measure might have been affected by earlier bad farming. But recall from Figure 2 that the free-slave boundary is not a significant predictor of erosion susceptibility.[19]

As the data permit, we can see broadly similar patterns in earlier years. We focus on 1860 because it is the year of greatest data availability before the Civil War. However, all of the earlier censuses had population and a few subcomponents, if the county was organized. The 1850 census also reported farm values. Figure 5 plots the year-specific slave-region coefficients for nonwhite and rural population density 1790-1860 and farm value per farm acre for 1850-60. The coefficients vary by year, especially in the whole sample, which is influenced by the emergent county boundaries in the western part. However, the general finding throughout the antebellum years is similar to what we report above.[20]

VI.C: Spatial Correlation

We now consider alternative strategies for assessing the precision of our estimates above, in light of the spatial correlation in the data. A county should not be considered independent of its immediate neighbors, because so many of their outcomes have determinants that are either common or highly correlated. The strategy above is to use 15 bins of longitude as clusters, which follows on the work of Bester, Conley, and Hansen (2011) as a computationally efficient procedure to account for spatial correlation, at least within the stated groups. The averages across these 15 groups

[19] The boundary is a significant predictor of depth to bedrock, as seen in Figure 2, and the coefficients indicate five to 10cm deeper soil on the free side. For comparison, a typical depth to bedrock in the Old Northwest is greater than the 152cm (60in) measured in the soil surveys. However, our inspection of the detailed raster data on bedrock depth indicate that this is a footprint of the terminal moraine (extent of glaciation) and not of the free-slave boundary.

[20] The patterns, for example, predate the enactment of the 1850 Fugitive Slave Act (passed on September 18). The collection of the 1850 US Census began on June 1, several months earlier. Similar results for population density hold in 1840 and before. For recent studies into the effects of the 1850 Fugitive Slave Act, see Allen (2015) and Lennon (2016). The stability of the gap in the rural population density speaks as well to the potential role of soil erosion. If southern planters were more extensively engaged in soil mining, one would expect relative population density to decline over time. It does not. We thank Edward Glaeser for bringing this observation to our attention.

themselves exhibit low spatial correlation, suggesting that the strategy is adequate to mop up the variation that is correlated across county observations. In Table 4, Panel A, we compare the estimated standard errors for a few clustering strategies. The first row contains the estimated coefficient and the second row contains the baseline standard error. The next row uses instead 10 groups of longitude as clusters, which inflates the standard error to some degree. The following row uses only five groups of longitude, for still larger standard errors. The statistical significance would be judged essentially the same under all three of the strategies, with the exception of farm value per county area, whose coefficient becomes marginally significant when using only five bins of longitude. In the next row we use states as the clustering variable. There is some justification for this inasmuch the policy under analysis (among others) vary at the state level. The strategy yields still larger standard errors, and results for rural population and farm value per county area are rendered marginally significant. For comparison, we also report standard errors under the assumption of independence; these are considerably smaller than those using the large clusters.

We then turn to a parametric approach for dealing with space: the Conley (1999) estimator. This estimator uses a predetermined band of distance around each observation and estimates the correlation within it. The estimator, which is analogous to the Newey-West estimator for time series, uses a kernel that tapers off to zero, linearly with distance, within the band. We show results from the Conley estimator in Table 4, Panel B. The typical distance from the center of a county to that of its neighbor is 5-15 miles, so we start with a 20-mile band. This allows an observation to be correlated with its immediate neighbors which, in turn, can be correlated with their immediate neighbors. As seen in the second row, the estimated standard errors hardly budge, as compared to the plain-vanilla errors estimated in the final row of Panel A. Doubling the band to 40 miles increases the estimated standard error by perhaps 30 percent. We present, in the remainder of the panel, results for bands out to 150 miles.

Kelly (2020) introduces an alternative parametric adjustment for spatial correlation, which we employ here. This method uses for the spatial kernel a flexible function governed by three parameters: the fraction of idiosyncratic noise, the smoothness of the function, and the range of influence. The latter two parameters are difficult to identify separately, so we adopt Kelly's three suggested choices of smoothness (kappa) and then use maximum likelihood to estimate the other two parameters. Results are found in Panel C of Table 4. Kelly-type standard errors are comparable to the baseline estimates and also to Conley-type errors estimates with a 100-mile band. The standard errors are more than double those based on an assumption of independence. This does not change the conventional statistical significance of any of the coefficients. These robustness results offer important reassurance.

VI.D: Falsification Test

Panel D of Table 4 reports results for a falsification test of our border design. It shows the coefficients for the main outcomes for regressions for samples analogous to the border sample but with pseudo-borders that are displaced by 50 miles north or 50 miles south of the actual boundary.[21] The magnitudes of the coefficients, which are strong at the actual boundary, become much smaller at the pseudo-borders. And in almost all cases, they are no longer statistically significantly different from zero.

VI.E: External Validity: Adding Changes-in-Slope terms

The external validity of the findings merits special attention. Above we argue that the northern edge of the slave region is highly suitable to be "free soil." The climate and geology are similar to the southern edge of the free zone, where free labor was thriving. But farther south, the environment might become so unsuitable to free labor that the effects diminish or reverse in sign. In Table 4, we assess this claim in two ways: (i) expanding the buffer around the boundary and (ii) allowing for a 'kink' at the boundary in addition to the 'jump' already used. Ideally, there would be a free-soil zone randomly placed in the Deep South for comparison. But this is not possible. Instead, this analysis uses the spatial trends estimated within each region.[22] For Panels A through D, we use the default specifications, but for buffers of 300, 450, 600, and 900 miles from the boundary. As we zoom out, the effect on nonwhite population is somewhat smaller, but the effects on white population and on rural population double. There emerges a large negative effect of slavery on total farm acreage, and the negative effects on land improved and farm value intensify.

We next test for a kink at the boundary in the effect of slavery. Specifically, while there might be a jump at the boundary, there could also be a change in the slope that attenuates or amplifies the effect as one moves farther south. The remainder of Table 4 reports the results for regressions including an intercept term—slavery legal—and a change-in-slope term—slavery legal*(distance to boundary/100). The specification employed is:

$$(3)\quad Y_i = \beta_1 * Slavery\_Legal_i + \beta_2 * Slavery\_Legal*Distance/100_i + \gamma_1 * Longitude_i + \gamma_2 * Longitude_i^2 + \gamma_3 * Longitude_i^3 + \gamma_4 * Distance_i + \gamma_5 * Distance_i^2 + \gamma_6 * Distance_i^3 + \beta_0 + \varepsilon_i$$

[21] We focus on the border county sample because the 150- and 300-mile samples for proposed pseudo-boundaries would include the actual boundary.

[22] This might be modeled as a set of underlying natural factors that move smoothly over space, and enter into productivity with differing weights by institution (free soil vs. slavery). This would generate a jump and a kink at the boundary in the spatial pattern of land value.

Note the change-in-slope term is in addition to the (smooth) spatial controls included in the baseline specifications. For the most part, the slope effects reinforce rather than counteract the change in the intercept.[23]

Figure 6 illustrates these geographic patterns using farm value per county area. Each dot represents a county in 1860. The marker size is proportional to county area, which is also used as a weight in the estimation of spatial trends. The various lines denote estimated spatial trends (appended in obvious ways to specification 3). The solid line is a quadratic fit, specific to each side of the boundary. The gap between these two curves is approximately 1.75, at the boundary. This is comparable to the estimates in Table 4 that use the widest buffer. The slopes at the boundary are positive for both curves, and their second derivatives imply maxima south of the border. The spatial trend for the slavery region peaks at roughly 125 miles south, which is largely within states that are themselves on the border. In contrast, the estimated quadratic for the free region peaks at around 550 miles south, which reaches into north Florida and east Texas. The dashed lines are extrapolations of said quadratics to the other region. The curve is uniformly higher if estimated with the free region versus with the slave region. The trend in the slave region peaks within the region. In contrast, the trend in the free region indicates higher land productivity as one moves south, with only a minimal indication that this trend is abating. These estimates do not support the view that free-soil institutions would only be a suitable substitute in the more temperate north. One complication is the border's direct effect, which might distort our estimates. To wit, we add dotted lines for extrapolations that only use counties more than 50 miles from the boundary. The patterns at the boundary are similar to those already described, and the extrapolation of the free-soil trend peaks even further south.

Finally, while the extrapolation south becomes more speculative as we move far away from the border, the majority of the activity in the slave region in fact takes place within our default samples. Consider how the median latitude changes if we use different weighting variables: by county area, the median is just south of the confluence of the Arkansas and Mississippi rivers; by farm value, the median lies in the Boot-heel region of Missouri, some 150 miles north. The median distance to the boundary is approximately 180 miles, if we weight by farm value, population, or improved acreage. Even if the weight variable is slave or non-white population, the median distance to the boundary is less than 300 miles. The 300-mile buffer contains approximately 70 percent of the improved acreage and of the farm value in the slave region. If the estimated treatment effects on farm value were to drop to zero (in contradiction to the estimates above) after 300 miles, there would nevertheless be a large, negative effect of the institution. Even if the effect

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[23] Note this is compatible with the Upper and Lower South having different land productivity, but this could be due to an underlying spatial trend, not the institutions.

south of this buffer was equal, but of opposite sign, the net effect would remain substantially negative.

VII. Agricultural Activities and Wealth Distributions

VII.A. Farm Output

Delving deeper into the Census of Agriculture allows us to observe crucial differences in farming operations, in crop choices and farm sizes. (We will return to running specifications 1 and 2, without changes-in-slope terms. And to avoid clutter, we drop displaying results for the donut sample.) Figure 7 graphs the point estimates and confidence intervals for key variables related to farm production activities in 1860. We examine the top 20 farm products in the 300-mile band around the border. We will refer to these as crops although four– butter, cheese, wool, and honey—are technically animal products. Note that the slave-free border was sufficiently far north that cotton, rice, and sugar cane are not among the top 20 farm products. The extent of the production activity in each county is normalized by total farm acreage (US Census Office 1864b).

Analysis of the crop data reveal that the small grains --wheat, rye, oats, barley, and buckwheat-- were less common in the slave region. Wheat was grown in both regions, indeed even on slave plantations (see Irwin 1988 and Wright 2006). But it was less common on the slave side. The gaps for rye and buckwheat were small, but that for barley very large. Animal products (and their inputs such as hay and clover seed) were also less common in the slave region. Corn showed no difference at the border and only small differences in the widest band (in line with the standard findings of economic history that southern farms and plantations in the antebellum period were generally self-sufficient in maize.) The crops that were more common in the slave region were tobacco and hemp. Indeed, the differences for tobacco are most apparent. Tobacco had year-round labor requirements with intensive activity levels in close proximity, which facilitated direct surveillance by supervisors (Gray 1933). In general, crops producing more revenue per acre were grown on the slave side (see US Census Office 1854, p. 176).

The patterns of specialization may be compared with the stated intentions of Thomas Jefferson. Jefferson was one of the authors of the Northwest Ordinance and promoted the idea that the country would be better off if it were populated principally by free yeoman farmers. Small-scale operators might be expected to be engaged in producing grain, dairy, and other diversified outputs. The producers on slave side had access to a technology that those on non-slave side did not—they could coerce non-family labor to join their work-force and attain a larger scale of operations with greater ease (see Fleisig 1976, Naidu 2020).

The distribution of farm sizes also looks different on the two sides of the border. Figure 8 uses the Census of Agriculture data to provide a contrast of scale of farm operations. Operations of

500-999 acres were significantly (in both statistical and economic terms) more common in the slave region. There is a lower prevalence of farms at the yeoman's scale, in the 50-99 acreage range. The gap is nearly significant at conventional levels at the border but becomes statistically significant at the 95-percent level for the widest band considered, within 300 miles.

VII.B: Household-Level Wealth Distributions

We can extend the analysis of property holding by looking at Census micro data on wealth (Ruggles et al. 2021a). In 1860, the Census asked free people about the value of the real property and personal property that they owned. This is the universe of free people. Personal property in this case includes enslaved African Americans, so there is a mechanical aspect to the change at the border. The panels of Figure 9 graph the probability density functions for wealth (measured on the log scale) in the border area in 1860. The panels do so for real property, personal property, and total property, by household. (Results are similar if we restrict to the rural areas.) Figure 9 reveals extra mass at the high levels of wealth on the slave side, both in personal property and in real property. The Figure also reveals missing mass starting around $2,000, which seems to be shifted out to above $10,000. Again, the small-scale property holders appear less prevalent in the slave region.

There is a large historical literature on the place of "Plain Folk" in the American South (Owsley 1949, Linden 1946, Wright 1970). They are the class of white property holders working their own land with family labor (and perhaps a small number of enslaved African-Americans). "Plain Folk" are a "middle class" element in a social structure made up of plantation owners, slaves, and poor landless whites. The existence of "Plain Folk" or yeoman farmers in the South is no longer under contest. The above findings indicate that such people made up a smaller fraction of free households in the Border South than in the Border North.

VIII: Measurement and Interpretation of County-Level Wage Rates

VIII.A: Wage Gaps at the Free-Slave Border

Slavery effects also appear in the returns to labor and the differences are striking. The 1860 Census of Social Statistics collected county-level data on wage rates for various occupations (Lebergott 1964, Margo 2000).[24] In addition to using the (relatively noisy) individual series, we

[24] The manuscript records include monthly wages of farm hands, daily wages of day laborers and carpenters, weekly wages of female domestics, and the weekly price of board for laboring men. Unfortunately, the schedules for Ohio, apart from one county, are lost. We supplement the sample with 1857 Ohio data for daily labor and farm hands (Ohio Board of Agriculture 1857, Ohio Commissioner of Statistics 1858). We convert the wages into daily equivalents by assuming a six-day week.

estimate the principal component of the natural logs of the five series to create a single, convex measure.[25] See Appendix G for details.

Figure 10 presents results for the effect of slavery on returns to labor. The wage gaps revealing higher returns on the slave side. A key initial observation is that regional differences in board are not the driver. The point estimates and confidence intervals for the county-level data on weekly board reveal the differences are not statistically significant. Turning to the specific wage series, we see the point estimates for female domestics were generally higher in the slave region; the confidence intervals, though wide, often lead to rejection of the hypothesis of no difference. Carpenter's wages were higher by statistically and economically significant magnitudes in the slave region. The results for day laborers show higher point estimates in the slave region. The confidence interval strays over and back across null hypothesis line. But we never see daily wages that were lower by statistically significant magnitudes in the slave region. The results for weekly farm wages show a gap that is positive and significant. The results without and with the Ohio supplementary data are not fundamentally different. Finally, we turn to the results for the estimated first principal component. Again, labor returns were higher by statistically and economically significant magnitudes in the slave region.[26]

The overall findings are striking: wages were about 10 percent higher on the slave side. Coercion might extract work from slaves at lower cost, but labor returns for workers on the slave side of the border were higher.

VIII.B: Interpreting the Results within the Rosen/Roback model.

There is a puzzle. A yeoman farmer from the East or from Europe coming down the Ohio River could unload on the left or the right bank. The land is essentially the same on either side. But on the southern bank, the land is cheaper and wages higher. What does this tell us about the preferences of the settlers?

We can interpret the results using the Rosen/Roback spatial equilibrium model (Roback 1982). Firms and (free) households pick their preferred locations. In the most general version of the

[25] To facilitate interpretation, we renormalize the principal component to be a convex combination. By convention, variable weights for principal components are vectors of unit length, meaning that their *squared* elements sum to one. This fails to produce a convex combination of what are, in this case, essentially similar objects: log wages. It instead implies a function that is homogeneous of some degree greater than one in the level of wages, analogous to a Cobb-Douglas with increasing returns to scale. To address these issues, we renormalize the variable weights to sum to one. We also wish all of the variables to have positive weights, so as to form a convex combination. This happens to be the case with these data, so there is no need to constrain the estimate further. As this weighting vector therefore points in the same direction as the conventional one for a first principal component, it yields the geometric mean of wages that best summarizes the variance in log wages.

[26] We examined whether the gaps were due to differences in human capital. For free workers identified as common laborers, farm laborers, carpenters, and domestic servants in the 1860 population micro-sample, literacy rates were lower on the slave side of the border. Accounting for human capital widened the gaps, rather than narrow them.

model, both firms and households use land.[27] In the variant that best fits our case, only firms (here farms) use land and households do not (as the land component of housing costs was negligible in rural areas). A free household's utility is affected by wages (positively) and amenities (positively). Farms' land rents (and land values) are determined by productivity (positively) and wages (negatively). The rents adjust to generate zero profits. The summary interpretation is that the observed combination of lower land values and higher wages is consistent with a strong household-side disamenity that free people associated with living and working in the slave region.[28]

The vast literature on "Free Labor" offers numerous reasons for such a disamenity (see, Ruffner 1847, Helper 1857, Foner 1970). One thing we know about slave societies is that the institution of slavery permeated all aspects of the society. Things were structured to accommodate, support, and perpetuate slavery and the interests of slaveowners. Those external effects can distort many other choices. A landless white might have to serve in the militia, or just worry about slave rebellions. Free workers might not want to work alongside slaves or just be in a place where the slavery existed. It is hard to distinguish between the different motives, but narrative evidence suggests that many yeoman farmers felt that the slave system did not work for them (Merritt 2017). Under slavery, governments emphasized enforcing order rather than providing services such as public education.[29] There were larger population flows of free persons from the slave side of the border to the free side throughout the antebellum period (see Appendix I for details.)

IX: Accounting for Slavery

The dominance of disamenity effects do not rule out negative effects of slavery on productivity as well. We examine here the role of several proximate determinants for farm values and then compare the magnitudes of slave wealth and of the gap in farm values. We find that farm improvements and higher wages explain much of the effect on farm values at the free-slave border. Differences in measured Total Factor Productivity (TFP) do not appear to explain much of the gap.

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[27] See Appendix H for details. In more common variant of the Rosen-Roback model, only households use land. A firm's profits are determined by productivity (positively) and wages (negatively). Firms enter until a zero-profit condition holds. A household's utility is affected by amenities (positively), wages (positively), land values (negatively) through the effect on housing costs which depend on density (positively). Households pick their highest utility location, driving land values to equalized utilities. Land values do not directly enter in the firm's profits, only in the household's utility through the density-dependent cost-of-housing effect. The predictions of the standard model are simple and intuitive: (1) the combination of higher land value and higher wages is associated with the higher productivity of local firms; whereas (2) the combination of higher land value and lower wages is associated with higher amenity values for local households.

[28] The puzzle identified here is obviously related to the "Easterlin paradox" regarding robust westward movement into the North Central region where income per capita was apparently below than the national average during the late antebellum period. See Easterlin (1960, 1961) and Margo (1999).

[29] Go and Lindert (2010) and Bleakley and Hong (2021) document markedly lower rates of antebellum school enrollment and attendance, respectively, by whites in the South than in the North. Bleakley and Hong report that the fraction of white children in 1860 attending school in the south was approximately 40 percent, which compares to more than 60 percent in the north, and there was little overlap in the distribution of state averages. Go and Lindert further report a relationship between voting rates and school enrollment in the North, but not in the South.

Nor do differences in pecuniary taxation. We then argue that, in the borderlands, the reduction of land value was of the same magnitude as the region's slave wealth. Looking at the border example brings the economic costs of the slave system into sharper light.

IX.A: Investments in Improvements

A sizeable proportion of the difference in farm values stems from more investment in land on the free side. We quantify two channels here. First, the higher rural population on the free side (about 50 percent more) would have required more housing. And there were likely more barns and other structures. The 1860 Census of Agriculture lumped land and buildings together in its farm value measure. Authorities report structures as being almost one-fifth of farm value. Subtracting the estimated value of buildings from the farm values yields an estimate of the value of "land alone" (see Gallman 1972, Primack 1975; Lindert 1989a, 1989b). Second, we observe the free side had substantially more improved acres per total farm acre. The literature offers various ways to adjust for this difference. We report two methods, based on the ratio and subtraction approaches (see Appendix J for details).

Table 6 reports estimates of the effects of slavery on land values after attempting to adjust for differences in buildings and land clearing. The estimated effects are everywhere negative and typically statistically significant. Taking the 300-mile buffer as example, the results of farm land (excluding building) indicate a 46 percent reduction, or $7.74 per acre, on the slave side. The results for farm land adjusting for improvements (in the first method), show a 36 percent reduction, or $4.20 decline per acre. The effects are larger in magnitude for the second method, but the estimation is less precise.[30] Thus, a sizeable fraction of the difference in farm values per acre is explained by differences in building values and land clearing, but a large fraction remains. Note differences in building and improvements were, in large part, outcomes of the institution of slavery.

IX.B: Total Factor Productivity in Agriculture

There is a vast literature on how the labor of coerced workers will be grudgingly given and how the ideas that generate long-run economic growth do not flow so readily in a slave economy.[31] But measured differences in agricultural TFP appear to explain only a small fraction of the

[30] The land value estimates utilize state-level parameters which make comparisons in the border sample problematic. The changes may be artificially sharp at the points where the parameters shift as in the border counties. Comparisons in the 150-mile sample and 300-sample are not so greatly affected.
The gaps in raw land values do have an east-west gradient. The slavery-related differential in higher in the settled east than in the frontier west. This is to be expected as the federal government sold the public domain in the west for the same price-- $1.25 per acre in cash—in both the free and slave regions.

[31] Slave labor, wage labor, and family labor (yeomanry) systems all had aspects that enhanced or impeded labor productivity: slavery was backed by coercion, although agency problems were commonplace; wage labor was plagued by agency problems as well, along with uncertain recruitment and retention; yeomanry solved an agency problem, but under capital constraints or with a limited span of control.

differences in land values at the border. We can estimate TFP in 1859-60 agriculture at the county level using the approach developed by Fogel and Engerman (1971, 1974). See Appendix J for details. The county-level estimates do largely replicate their North-South comparisons. Many of the critiques directed against their regional analysis are less relevant for comparisons at the border. Absent here are the large differences in latitude, affecting the length of the growing season, types of crops grown, or hours of labor worked per year. Nor are there large differences in soil quality. The Border South did not grow the plantation crops, such as sugar, rice, and cotton, thought to be characterized by substantial economies of scale. Special conditions in the cotton sector during the 1859 crop year—the coincidence of high demand with abnormally high yields per acre—do not cloud the border comparison (see Fogel and Engerman 1977, 1980; David and Temin, 1979; Fogel 1989; Wright 1978, 2006).

To calculate TFP, we use county-level agricultural labor force estimates developed by Thomas Weiss, working with Lee Craig (Craig and Weiss 1998). We report estimates based on Weiss's numbers directly as well as a variant created to reflect the higher agricultural labor force participation rates assumed by Stanley Lebergott (1966). We also derive results where the contribution of improved land is up-weighted in line with the considerations raised above. Table 6 reports the effects of slavery of estimated TFP in the border sample. (National TFP is centered around unity.) In general, the slavery effect is negative, but small. In the 150-mile buffer sample, the measured effects are on the order of -2 to -5 percent, and not statistically significantly different from zero. In the 300-mile buffer, the effects are larger in magnitude, around -10 percent. As might be expected, the numbers calculated using the Lebergott method are less favorable to the slave side than those using Weiss's method for labor or using higher weights for improved land.[32] But the overall take-away message is the productivity gap at the border was small and can account for only a lessor fraction of land value gap.

IX.C: The Price of Free Labor

Free labor's preference for free soil explains a substantial part of the differences in farm values. Recall that, on the slave side, farm values per acre were roughly 55 percent lower and wage rates about 9-10 percent higher. The higher wage rates would, other things being equal, result in lower land rents and land values. To a first approximation, the elasticity of one factor to the other would be the ratio of the labor share to the land share in net output. A given percentage increase in

[32] A major effect of coercion was to increase labor force participation, especially of prime-age women, in market production. This represents an increase in inputs per capita and will not be reflected directly in TFP.

the price of a mobile factor affects total cost in proportion to its cost share; the increase in total cost is incident on land (the immobile factor) in inverse proportion to its own cost share.[33]

For the purposes of this analysis, we can focus on the free side of the border and ask what land rents/values would be if wages were at the levels prevailing on the slave side. Estimates of the ratio of the labor share to the land share in nineteenth-century US agriculture vary greatly—from 1.5 to 3.2.[34] Our read of the evidence suggests a preferred ratio of 2. Using this number, the higher wages would reduce land rents by 18-20 percent. If the ratio was 3, the reduction would be 27-30 percent, by the same reasoning. Given the similarities in regional interest rates, the effects on land values should be proportionate to the effects on rents.[35] The wage differences, then, explain virtually all of the land value gap remaining after our previous adjustments (see Table 6).

IX.D: Taxes

It does not appear the land values and wages can be easily explained by higher overall rates of taxation in the slave areas. One can compare tax revenues collected relative to wealth reported by state in the 1860 federal census (US Census Office 1866, pp. 511-12). The revenue numbers include the taxes levied by different levels of state and local governments within each state.

We compare tax collections to reported real estate wealth or all reported wealth, which includes the value of slaves. For both measures, the ratio was lower in the states of the Border South (DE, DC, VA, KY, MO) than those in the Border North (PA, OH, IN, IL, IA). The ratio of taxes collected to all wealth was 0.0040 in the Border South and 0.0065 in the Border North, substantially lower in the slave areas. The ratio of taxes collected to real estate wealth was 0.0077 in the Border South and 0.0089 in the Border North, lower in the slave areas. Both the relative and absolute magnitudes of these numbers are inconsistent with a story that higher state and local tax rates in the South created the land value differences. Non-pecuniary taxes, such as militia service, or different expenditure patterns, such as lower support for public schools, remain possible explanations (and are captured, in part, in the household disamenity story). Spending on internal improvements, however, are an unlikely part of the story, because border counties, especially those on rivers, would have similar transport access.

IX.E: Cassius Clay's Calculation

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[33] See Appendix A for a formal derivation. There we show that, at an interior solution, the second-order effect amplifies the impact on the land price. Therefore, this calculation is likely a lower bound.

[34] US Treasury (1871) land rental data yield a ratio of 1.5 (=0.5/0.33). Fogel and Engerman (1974, vol. 2, p. 132) used a ratio of 2.32 (=0.58/0.25); this revised their earlier (1971, p. 358) ratio of 3 (=0.6/0.2). Gallman (1972, p. 205) put the ratio of labor to farm real estate at 3.13 (=0.704/0.225) and the ratio of labor to land excluding buildings at 4.17 (=0.704/0.169). Atack and Bateman (1987, p. 193) offer a ratio of 2 (=0.6/0.3) as a plausible conjecture.

[35] Bodenhorn (2000, ch. 4) shows antebellum regional capital markets were well integrated, with roughly equalized interest rates.

With any welfare-enhancing reform, there are usually incumbent interests that stand to lose. Our estimates above suggest that land on the slave side of the free-slave boundary would have been more valuable as free soil. But would this gain from switching have been enough to compensate the slaveowners? Cassius Clay, the noted Kentucky abolitionist and sometime slaveowner himself, believed that land values would rise more than the loss in wealth if the enslaved were liberated. In 1834, Clay opined that, for the emancipation of his slaves: "I shall ask nothing in return but the enhanced value of my land which must ensure gradually from the day that we become indeed a free and independent state (quoted in Martin 1918, p. 112)." In 1845, Clay added: "Kentuckians will be richer in dollars and cents by emancipation, and slaveholders will be wealthier by the change (Martin 1918, p 114)."[36]

Does this claim hold up to further inspection? As a simple first exercise, we note that in 1860 farm values were lower on the slave side by around $7.99 (se=2.79) per county acre while there were 5.5 more slaves per thousand acres.[37] The reduction in farm wealth was the equivalent of about $1450 per slave, which was almost double the typical price of a slave in the region. This suggests that, even before considering the value of freedom to the enslaved, there was enough economic surplus from abolishing slavery in the borderland to compensate the losers from such a policy.[38] But a part of the higher farm values in the North was due to costly improvements and buildings; how to treat their value and potential appreciation are open questions. If the differences in raw land values capture all of the potential appreciation effects, based on the estimates above, the surplus would not be sufficient. Other forms of real property must also rise in value, as they likely would, for Clay's proposal to work.

In Clay's view, there would be no need to compensate slaveowners directly, because they were also landowners. This second claim is stronger. To explore this claim, we inspect the IPUMS 1850 linked sample of slaves and slave-holdings which can be linked to the 1-Percent Population sample (Menard et al. 2004, Ruggles et al. 2021b). For free households, the Census recorded real estate wealth and slave-holdings by the enslaved person's age and gender. Using the 1850 prices for the Old South by demographic characteristics reported in Historical Statistics (Carter et al. 2006, Series Bb215-216), we can construct household slave wealth. We can then compare the distribution of real estate wealth and slave wealth to gauge the potential winners and losers from Clay's emancipation proposal. In the 1850 linked sample, total real estate wealth was 1.9 times slave

[36] Tallant (2003, pp. 100-101) notes such claims were common in antebellum Kentucky. Chase and Sanborn (1856, pp. 42-45) advance a similar argument for the entire border region.
[37] Clay had his own estimate: "I assert from my own knowledge, that lands of the same quality in the free, are from one hundred to one hundred and fifty per cent higher in value than in the slave states" (quoted in Martin, 1918, p. 114).
[38] Ransom and Sutch (1988) estimate the average price of a slave nationally in 1860 to around $800, a high value following two decades of appreciation. The 1860 value of the typical enslaved person in the border region was $685, using their Old South valuations. Clay's math would have been even more favorable when he made this claim.

wealth. A real estate appreciation rate above 53 percent would produce real estate gains covering slave wealth loses. Table 7 reports the distribution of the population, in all households and slaveholding households, in the 300-mile buffer region. Enslaved African-Americans, who bore the brunt of the system's oppression, would clearly benefit from its end. A substantial fraction of free southerners lived in households reporting neither slave wealth nor real estate wealth. The policy change would not affect their wealth status directly. Another large fraction lived in households reporting real estate wealth but no slave wealth. They would gain from real estate appreciation and lose nothing from emancipation. The tradeoff that Clay highlighted affected those living in households reporting both slaves and real estate. The figures in Table 7 indicate some would gain—with the fraction depending on the assumed percentage real estate appreciation. But given the distribution of real estate and slave holdings and the range of plausible appreciation rates, most slave holders would lose.

How would the timing of possible institutional change affect these calculations? As Cassius Clay assumed, the rise in farm value would be gradual, which would reduce the present value of the appreciation. But emancipation proposals floating around Upper South at the time would also have been gradual and reduced the cost to slaveowners. Thomas Jefferson Randolph (namesake of his famous grandfather) proposed in 1832 a gradual emancipation in which those born after 1840 would receive freedom as an adult (Freehling 1967). Henry Clay (distant cousin of Cassius) proposed a similar scheme in Kentucky in 1849 (Martin 1918).[39] Slaveowners would have ample opportunity to sell their slaves out of state before then, so gradualism would also limit the economic loss to slaveowners (and the restoration to the enslaved of what both Randolph and Clay acknowledged was a natural right to freedom).

X. Conclusion

In the mid-twentieth century, economists dropped into the historical debates about antebellum US slavery with systematic analyses of its profitability and productivity (Conrad and Meyer 1958; Fogel and Engerman 1971, *inter alia*). Earlier historians had argued that slavery was unprofitable and therefore moribund as a mode of production. In that sense, it bore more resemblance to feudalism, with its attention to rigid social hierarchies, than to the capitalism emergent elsewhere in the world. Economists reported a variety of evidence to the contrary: slave owners actively sought and achieved economic gains, agricultural operations using slave labor were competitive, and slave prices reflected underlying considerations of revenue and cost. Therefore, while slavery was, as Jefferson's first draft of the Declaration of Independence stated, an 'execrable

[39] Clay's proposal was not adopted by the Kentucky Constitution Convention, but delegates voted nearly unanimously to affirm a statement that "slavery as it exists by law in this state is injurious to the prosperity of the Commonwealth" along with moral objections familiar to the modern reader (Martin 1918, p. 126).

commerce', it was not associated with unproductive misallocation of resources (so went their argument).

Later, North (1981) brought to the fore the idea that 'institutions' are fundamental determinants of economic performance. This idea has proved useful in understanding the large disparity of incomes per capita across countries, for example. In this framework, there could be disparities across countries or regions even if locally markets and firms are behaving as in the textbook model of competition, maximization, etc. Instead, a place with weaker institutions suffers from a systemic reduction in productivity.

These two strands came together in the work of Engerman and Sokoloff (2011), who argued that historical labor coercion constrained institutional development, even after slavery ended. They argue that the slave societies of the Americas were indeed quite productive early on, but that they grew more slowly than free-soil societies in the past century and a half. Societies with labor coercion (slavery, serfdom etc.) are often the last to acquire the modern institutions–depersonalized rule of law, competitive markets, universal suffrage, mass public education, public health and sanitation, etc.–associated with economic growth, enlightenment, and human flourishing. The story is one of path dependence. Engerman and Sokoloff argue that labor coercion might have been the highest productivity mode in colonial times, but it left behind institutions unable to adapt to modern economic growth.

Our results indicate instead that the path dependence started before slavery ended, at least in the US free-slave borderlands. Slavery endured not just by the coercion of the slaveowner, but by the force of the state, which had to become quite intrusive. Ira Berlin (1998) wrote that 'slave societies' were not just 'societies with slaves,' but rather societies in which every aspect was affected by protecting slaveholder's interests. The stark differences at the border highlight that the slave system depressed land productivity and repulsed potential settlers and migrants. Free labor demanded a wage premium to be on the slave side and those free-to-choose preferred (and improved) otherwise-comparable land on the free side. Amazingly, in the area of this study, the reduction in land value associated with slavery was of a similar magnitude as the value of slave wealth itself.

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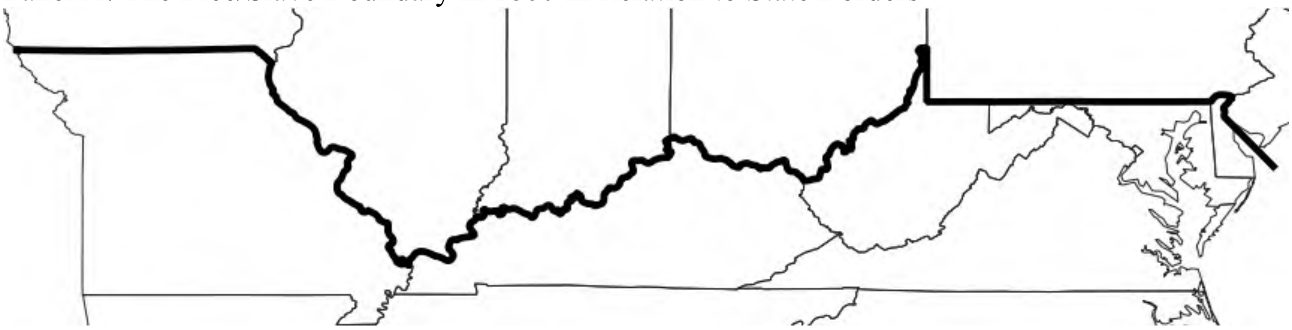
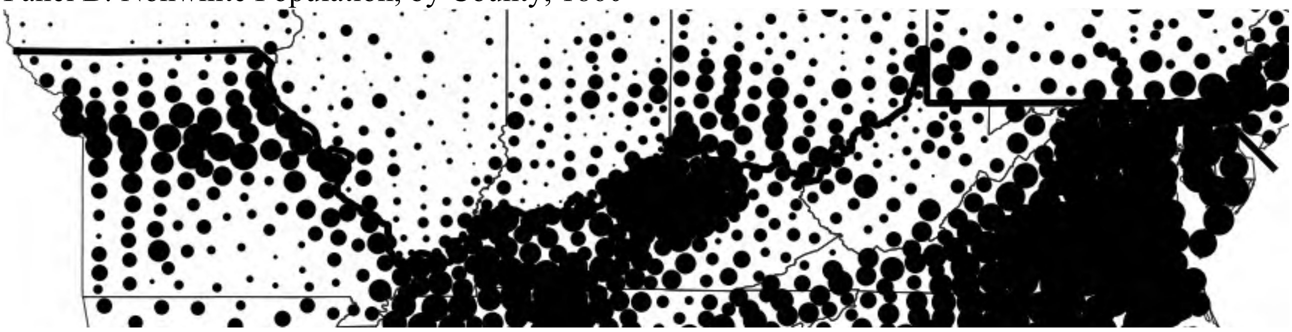
Figure 1: The Borderlands between Free and Slave Sections of the United States

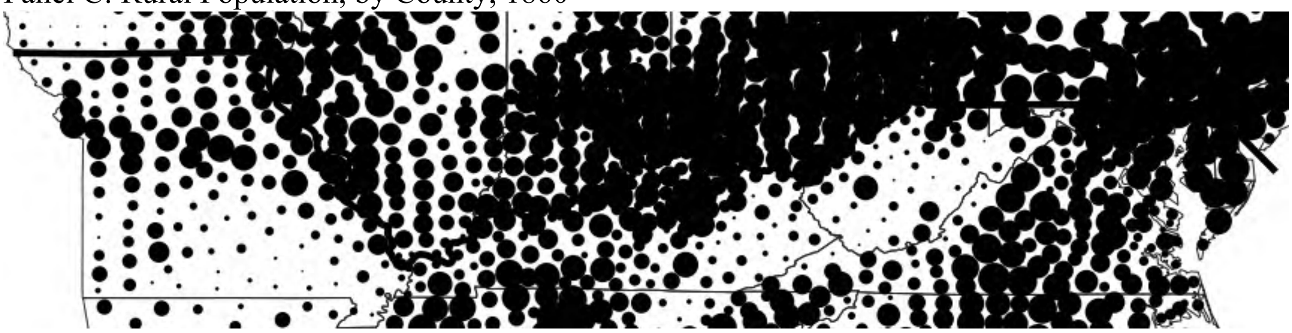
Panel A: The Free/Slave Boundary in 1860 in Relation to State Borders



Panel B: Nonwhite Population, by County, 1860



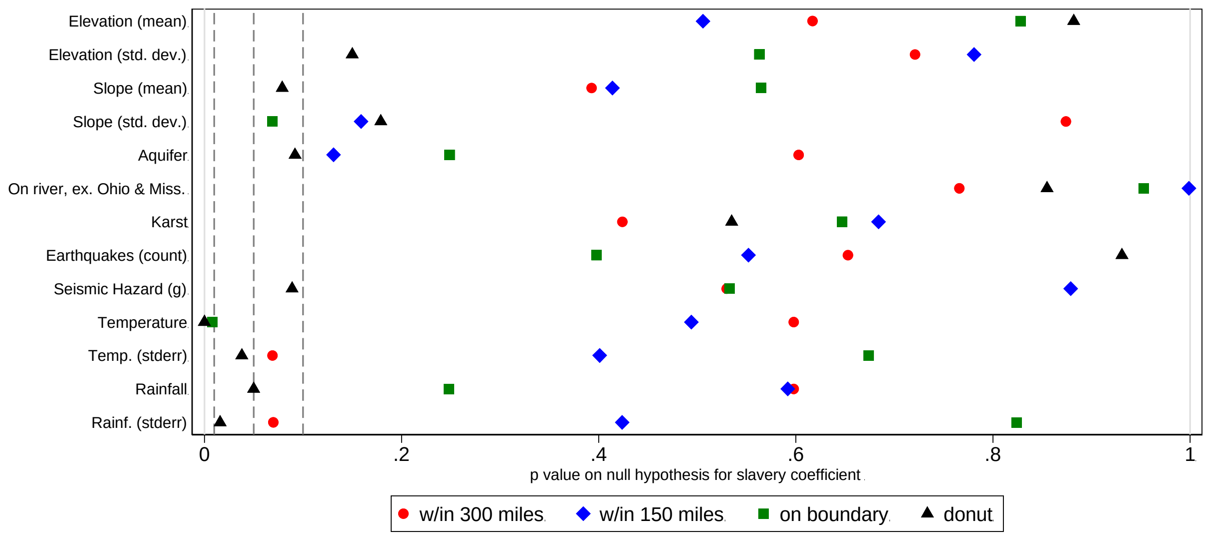
Panel C: Rural Population, by County, 1860



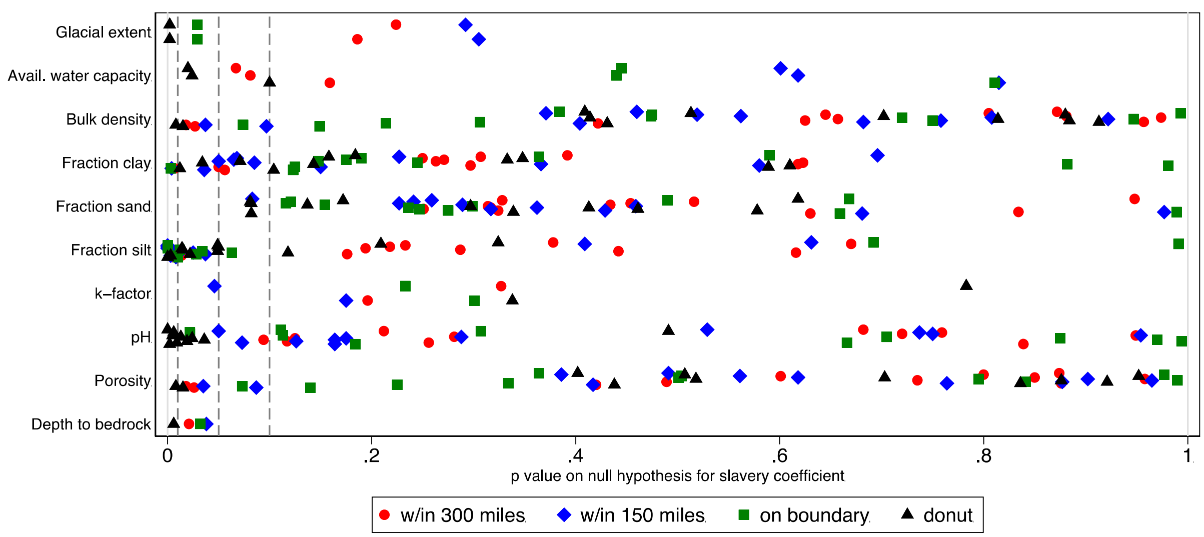
Notes: This figure uses as a base map the 1860 free/slave boundary, the 1860 state borders, and the later border of West Virginia for reference. These features are displayed by themselves in Panel A. (See Appendix A for details on the measurement of the free/slave boundary.) The remaining panels display 1860 county-level data using dots on top of the base map. The dots are proportional to the percentile of the indicated outcome. Each dot is placed at the respective county's centroid. The source for the spatial data is the National Historical Geographic Information System (NHGIS, Minnesota Population Center, 2011). The population data are based on census counts compiled in ICPSR study #2896 (Haines, 2010). Panel B presents the total non-white population, which principally consists of blacks in the displayed region. Panel C presents the total rural population, defined as total county population minus population in urban places with at least 2500 inhabitants.

Figure 2: Environmental Factors

Panel A: Miscellaneous

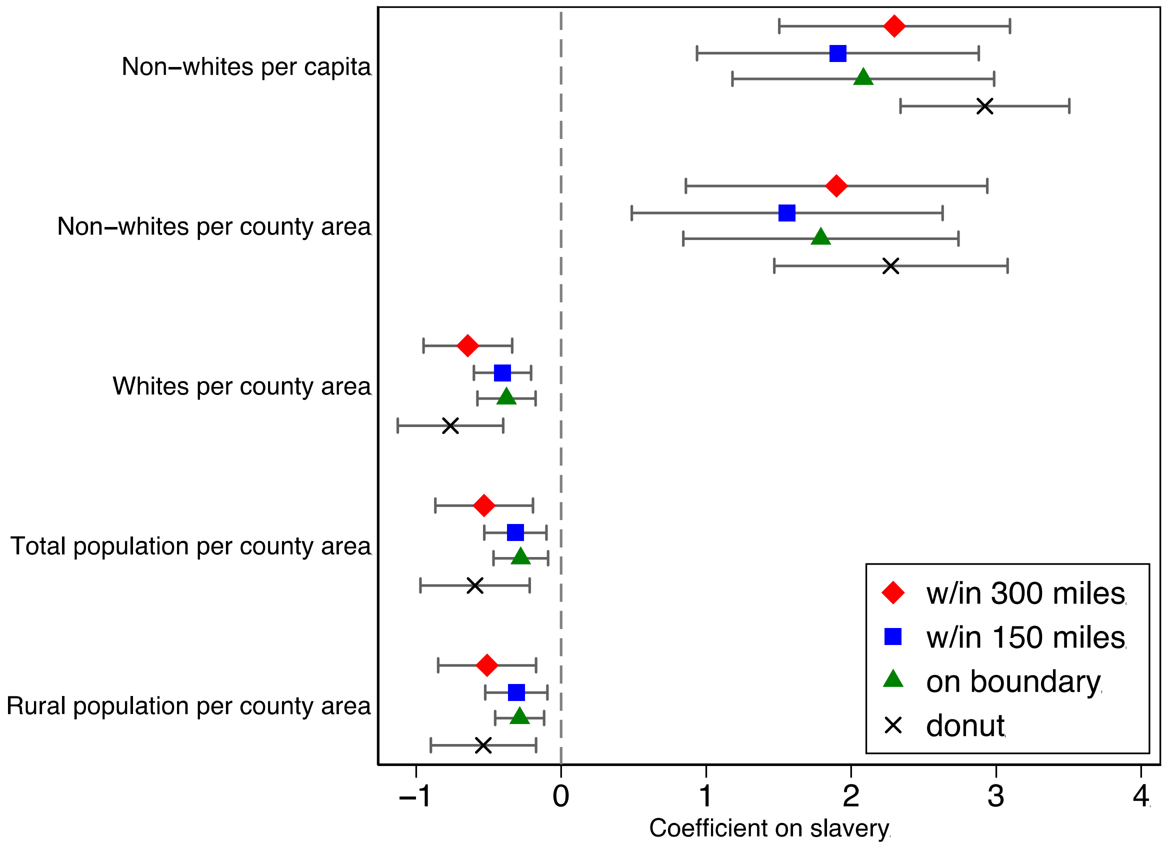


Panel B: Soil Variables (by group)



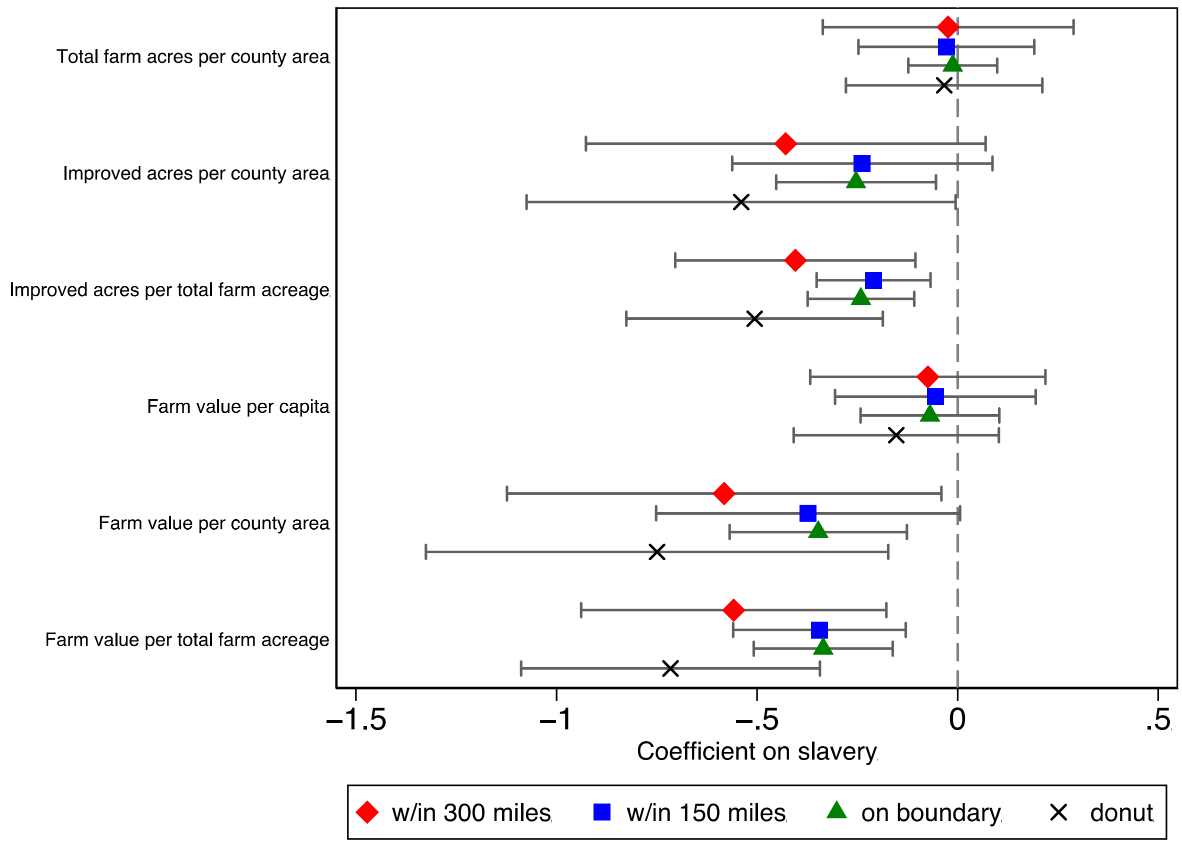
Notes: This figure presents probability values for the null hypotheses that the coefficient on slavery equals zero. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol is associated with the test of the null hypothesis for the outcome indicated in the row label and for various samples of counties. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed lines denote standard cutoffs at 1%, 5%, and 10%. See the text for variable sources and definitions.

Figure 3: Population



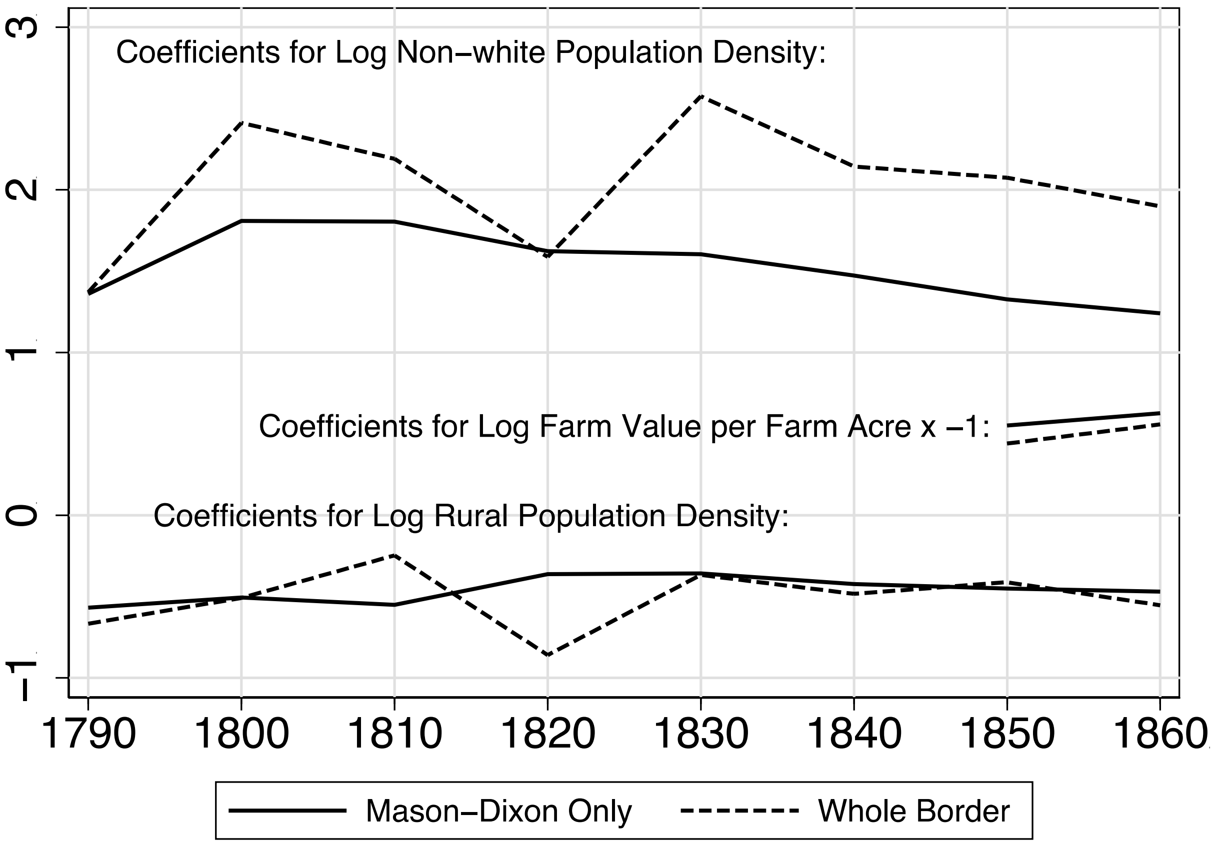
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. The outcomes are transformed into natural logarithms.

Figure 4: Land Use and Land Value



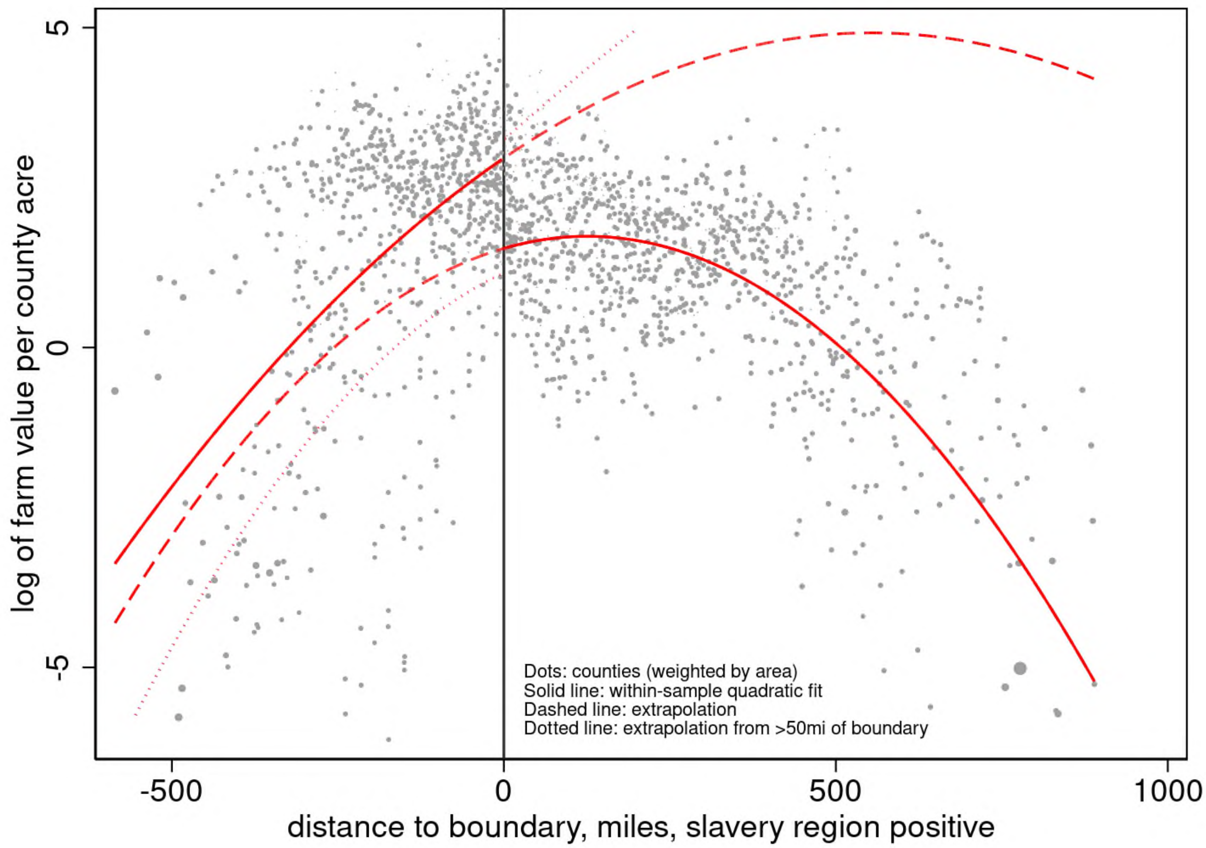
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero.

Figure 5: Effects on Nonwhite and Rural Population, Various Years



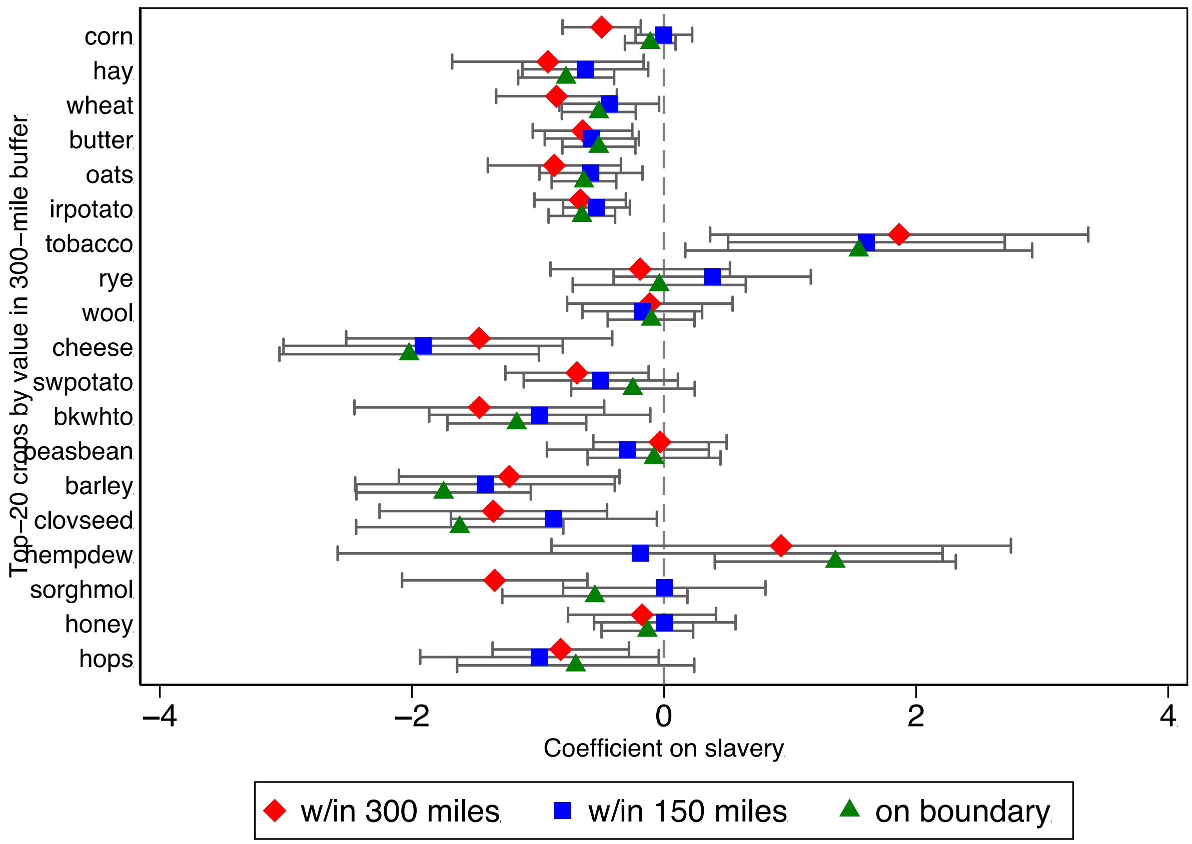
Notes: This figure presents point estimates for the coefficient on slavery for the outcomes indicated in the graph and for various samples of counties. The regression specification is the default: polynomial controls for longitude and for distance to the border, clustered errors by 15 bins of longitude, and weights according to land area. The base sample consists of counties in the 300-mile buffer. The "whole border" sample uses all of the available counties in each year. The Mason-Dixon sample uses only those counties whose closest free-slave border abuts Pennsylvania or New Jersey. (All of the land in the 300-mile buffer is covered by a county by 1810. All of the land in the Mason-Dixon sample is covered by counties for 1790 forward.)

Figure 6: Farm Value and the Boundary



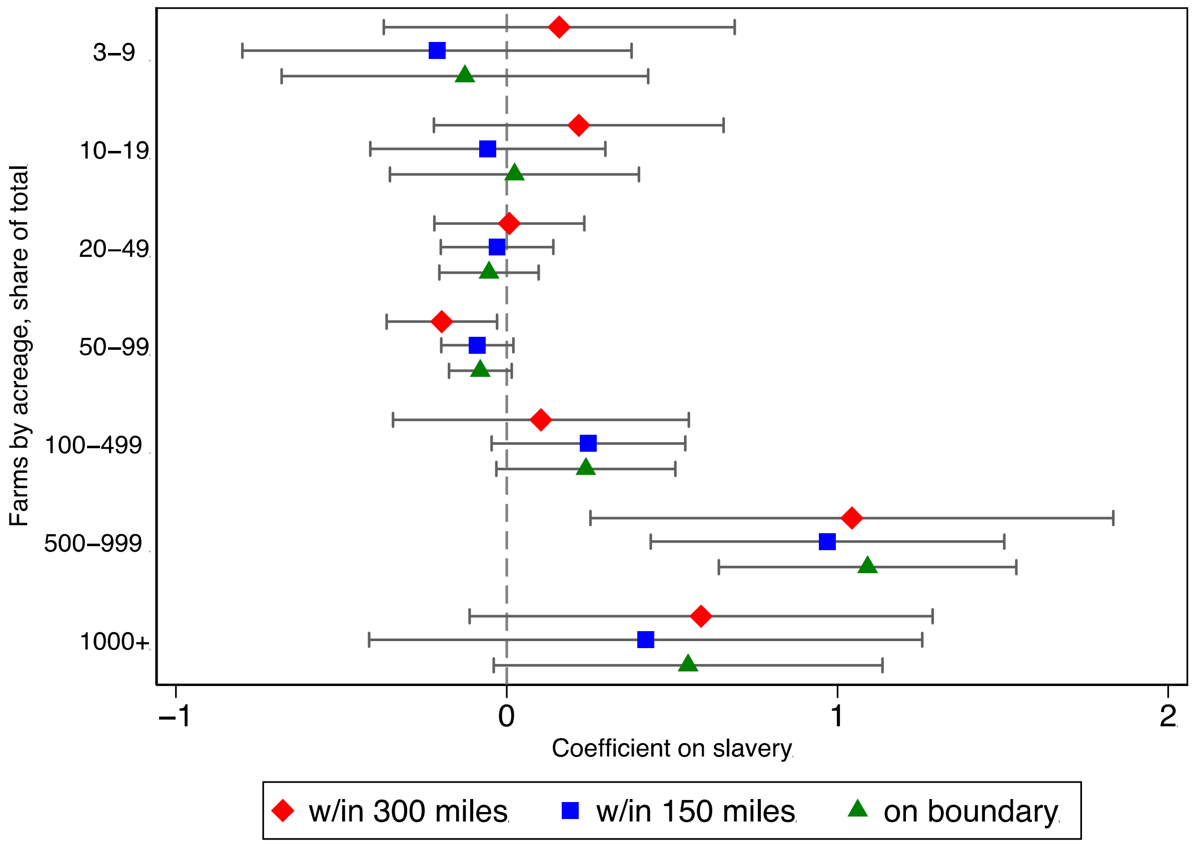
Notes: This figure compares the natural logarithm of farm value per county acre with the distance to the free-slave boundary. Dots, which denote 1860 values, are proportional to county area. The lines are estimated quadratic spatial trends: solid, within-sample fitted lines; dashed, extrapolations to the other region; dotted, extrapolations estimated with counties at least 50 miles away from the boundary. All estimates are weighted by county land area. See the text and appendices for data descriptions and sources.

Figure 7: Crops



Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero.

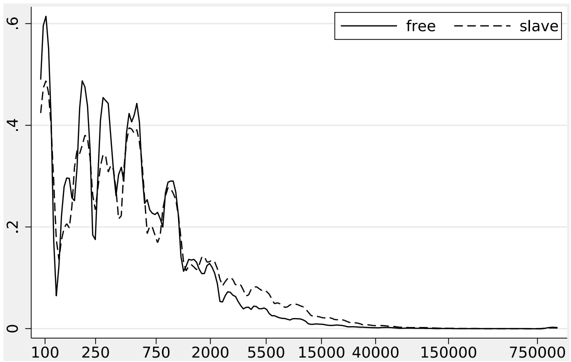
Figure 8: Farm sizes



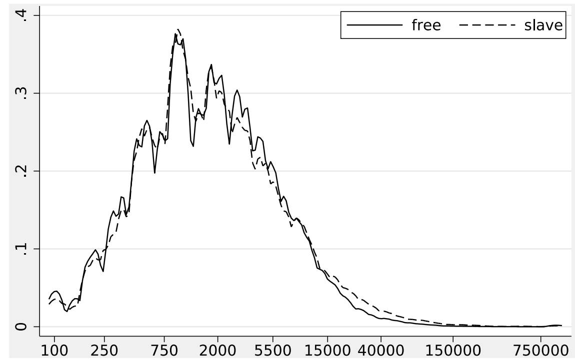
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero.

Figure 9: Wealth at the household level

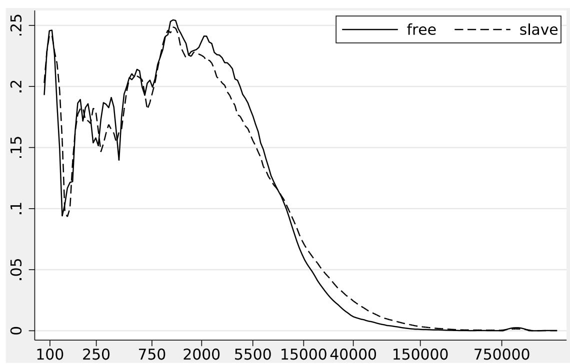
Panel A: Personal Property



Panel B: Real Property

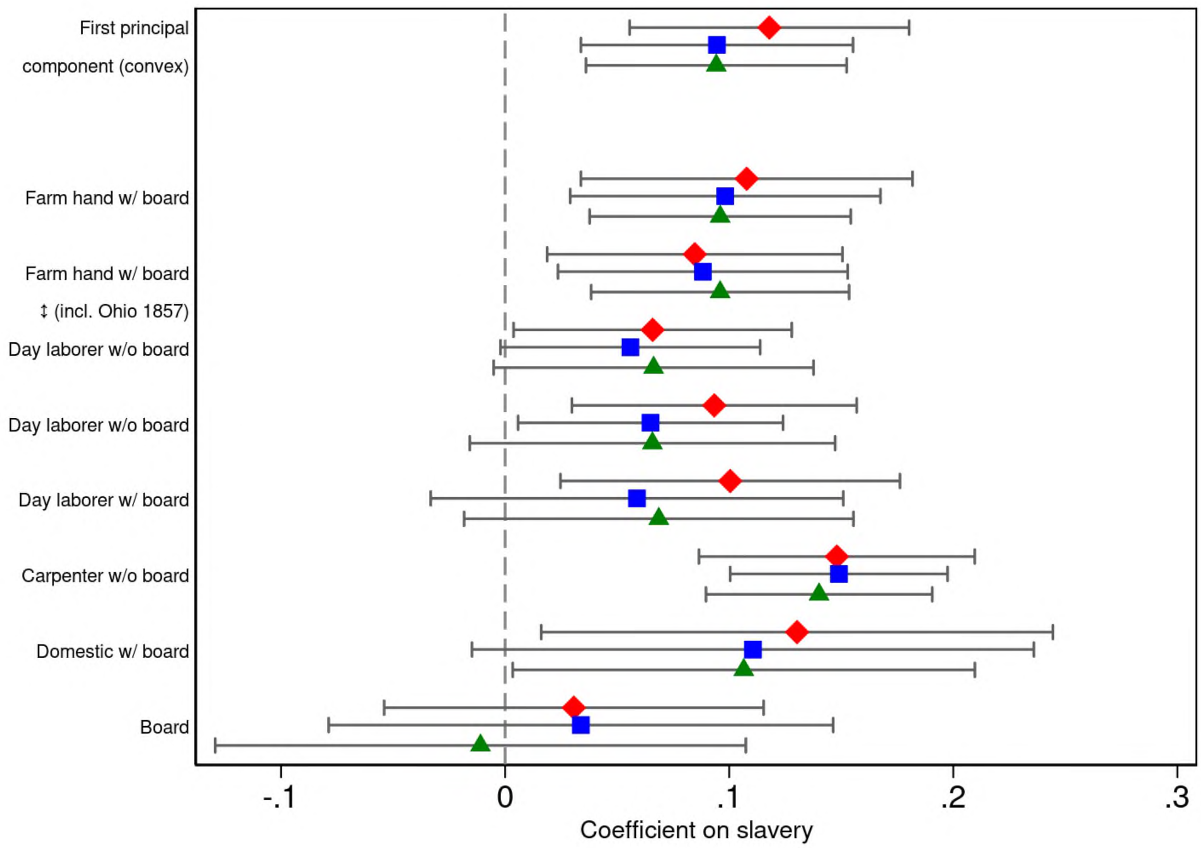


Panel C: Total Property



Notes: This figure presents estimates of the probability density function for log wealth at the household level in the border counties in 1860. As distinct from preceding figures, these are estimated using the microdata from the full-count 1860 census.

Figure 10: Wages (natural logs)



Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero.

Table 1. Summary statistics, select variables and samples.

Variable	Units	Whole			Free side			Slave side			Difference in mean
		Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	
Panel A: Counties within 300 miles of boundary											
Nonwhite Population,	Per Thous.	[1362]	5.3	(17.7)	[659]	0.9	(8.7)	[703]	9.6	(22.5)	-8.7
per County Acre	Logs	[1280]	-7.0	(2.4)	[579]	-8.6	(2.0)	[701]	-5.6	(1.7)	-3.0
White Population,	Per Thous.	[1362]	46.9	(342.1)	[659]	69.0	(467.0)	[703]	25.2	(130.3)	43.9
per County Acre	Logs	[1362]	-3.7	(1.2)	[659]	-3.4	(1.5)	[703]	-4.0	(0.7)	0.57
Rural Population,	Per Thous.	[1362]	41.1	(30.9)	[659]	51.1	(37.1)	[703]	31.2	(18.8)	19.8
per County Acre	Logs	[1357]	-3.6	(1.1)	[656]	-3.5	(1.5)	[701]	-3.7	(0.7)	0.18
Total Farm Acreage,	Levels	[1356]	0.59	(0.29)	[656]	0.55	(0.29)	[700]	0.63	(0.29)	-0.07
per County Acre	Logs	[1356]	-0.79	(1.00)	[656]	-0.97	(1.26)	[700]	-0.61	(0.61)	-0.36
Improved Acreage,	Levels	[1356]	0.41	(0.20)	[656]	0.51	(0.20)	[700]	0.32	(0.15)	0.19
per Farm Acre	Logs	[1356]	-1.03	(0.57)	[656]	-0.78	(0.51)	[700]	-1.27	(0.51)	0.49
Farm value ($),	Levels	[1356]	11.57	(14.01)	[656]	15.71	(17.19)	[700]	7.51	(8.12)	8.20
per County Acre	Logs	[1356]	1.75	(1.48)	[656]	1.95	(1.81)	[700]	1.54	(1.03)	0.41
Farm value ($),	Levels	[1356]	17.50	(37.36)	[656]	24.05	(51.43)	[700]	11.07	(9.27)	12.98
per Farm Acre	Logs	[1356]	2.53	(0.81)	[656]	2.92	(0.72)	[700]	2.15	(0.70)	0.77
Panel B: Counties on the boundary											
Nonwhite Population,	Per Thous.	[142]	4.2	(6.6)	[71]	1.9	(3.1)	[71]	6.8	(8.4)	-5.0
per County Acre	Logs	[140]	-6.9	(2.1)	[69]	-7.6	(2.1)	[71]	-6.0	(1.8)	-1.6
White Population,	Per Thous.	[142]	67.3	(83.4)	[71]	77.3	(88.3)	[71]	56.0	(76.4)	21.3
per County Acre	Logs	[142]	-3.0	(0.7)	[71]	-2.8	(0.7)	[71]	-3.2	(0.7)	0.42
Rural Population,	Per Thous.	[142]	55.8	(33.4)	[71]	64.4	(36.3)	[71]	45.9	(26.8)	18.6
per County Acre	Logs	[142]	-3.1	(0.6)	[71]	-2.9	(0.6)	[71]	-3.2	(0.6)	0.33
Total Farm Acreage,	Levels	[142]	0.65	(0.19)	[71]	0.66	(0.20)	[71]	0.64	(0.18)	0.02
per County Acre	Logs	[142]	-0.49	(0.39)	[71]	-0.48	(0.38)	[71]	-0.51	(0.40)	0.03
Improved Acreage,	Levels	[142]	0.47	(0.17)	[71]	0.52	(0.16)	[71]	0.41	(0.17)	0.11
per Farm Acre	Logs	[142]	-0.83	(0.39)	[71]	-0.70	(0.34)	[71]	-0.97	(0.40)	0.26
Farm value ($),	Levels	[142]	17.22	(18.02)	[71]	20.41	(20.76)	[71]	13.56	(13.52)	6.85
per County Acre	Logs	[142]	2.42	(0.93)	[71]	2.61	(0.93)	[71]	2.21	(0.88)	0.40
Farm value ($),	Levels	[142]	23.89	(20.38)	[71]	27.68	(22.41)	[71]	19.56	(16.95)	8.11
per Farm Acre	Logs	[142]	2.91	(0.69)	[71]	3.09	(0.66)	[71]	2.72	(0.67)	0.37

Notes:

Table 2: Sensitivity analysis, select variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcomes (in natural logarithms):	Nonwhites per county acre	Whites per county acre	Rural population per county acre	Total farm acres per county area	Improved acres per total farm acre	Farm value per county acre	Farm value per total farm acre
Panel A: Reweighting and recoding of zeros							
Baseline	1.899	-0.644	-0.511	-0.024	-0.405	-0.582	-0.558
	(0.485)	(0.142)	(0.157)	(0.146)	(0.140)	(0.252)	(0.177)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Weight by Rural Population	2.036	-0.580	-0.365	0.045	-0.212	-0.380	-0.425
	(0.362)	(0.100)	(0.0817)	(0.0593)	(0.0867)	(0.147)	(0.132)
	[1275]	[1357]	[1357]	[1352]	[1352]	[1352]	[1352]
Unweighted	1.993	-0.533	-0.431	-0.035	-0.278	-0.429	-0.394
	(0.459)	(0.145)	(0.132)	(0.122)	(0.133)	(0.220)	(0.168)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Assign zeros to minimum	1.927	-0.661	-0.513	-0.068	-0.428	-0.629	-0.586
	(0.521)	(0.150)	(0.168)	(0.179)	(0.135)	(0.265)	(0.171)
	[1364]	[1364]	[1364]	[1364]	[1364]	[1364]	[1364]
Panel B: Additional spatial controls							
Dummies for 5 quantiles of longitude	1.860	-0.641	-0.516	-0.023	-0.419	-0.600	-0.577
	(0.505)	(0.138)	(0.157)	(0.146)	(0.144)	(0.258)	(0.184)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Dummies for 10 quantiles of longitude	1.866	-0.640	-0.510	-0.023	-0.416	-0.598	-0.575
	(0.508)	(0.136)	(0.155)	(0.146)	(0.145)	(0.259)	(0.185)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Dummies for 15 quantiles of longitude	1.876	-0.653	-0.522	-0.034	-0.418	-0.607	-0.572
	(0.514)	(0.129)	(0.147)	(0.140)	(0.146)	(0.255)	(0.186)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Add cubic polynomial in latitude and longitude	1.873	-0.571	-0.455	0.003	-0.374	-0.506	-0.509
	(0.508)	(0.120)	(0.137)	(0.132)	(0.130)	(0.193)	(0.148)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Variables from Panel A of Figure 2	1.982	-0.533	-0.407	0.005	-0.327	-0.429	-0.434
	(0.508)	(0.130)	(0.137)	(0.136)	(0.121)	(0.243)	(0.171)

	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Depth to bedrock	2.109	-0.670	-0.471	0.011	-0.367	-0.498	-0.509
	(0.427)	(0.143)	(0.151)	(0.154)	(0.125)	(0.236)	(0.160)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Soil variables from Panel B of Figure 2	1.665	-0.520	-0.311	0.186	-0.315	-0.346	-0.532
	(0.389)	(0.137)	(0.126)	(0.0938)	(0.102)	(0.198)	(0.154)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Fraction glaciated	1.962	-0.514	-0.383	0.119	-0.346	-0.396	-0.515
	(0.488)	(0.179)	(0.179)	(0.142)	(0.140)	(0.258)	(0.181)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Fraction glaciated (excl. Driftless)	1.975	-0.525	-0.397	0.107	-0.343	-0.402	-0.509
	(0.488)	(0.160)	(0.163)	(0.131)	(0.138)	(0.248)	(0.179)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Fraction in Public Land Survey System (PLSS)	1.712	-0.682	-0.517	-0.059	-0.364	-0.561	-0.502
	(0.458)	(0.131)	(0.147)	(0.121)	(0.150)	(0.246)	(0.171)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Panel C: Outcome variables in levels (per acre), various estimators							
Mean (OLS)	0.006	-0.040	-0.021	0.017	-0.133	-7.988	-11.050
	(0.00207)	(0.0182)	(0.00533)	(0.0502)	(0.0476)	(2.785)	(3.923)
	[1362]	[1362]	[1362]	[1356]	[1356]	[1356]	[1356]
Median (Quantile Reg.)	0.002	-0.028	-0.019	-0.030	-0.174	-5.132	-9.062
	(0.000643)	(0.00320)	(0.00329)	(0.0369)	(0.0309)	(1.229)	(1.613)
Panel D: Displaced Border as a Falsification Test							
Boundary displaced by -50 miles	0.330	0.079	0.091	0.072	-0.004	0.126	0.054
	(0.213)	(0.0588)	(0.472)	(0.0461)	(0.0532)	(0.129)	(0.0927)
	[133]	[140]	[140]	[140]	[140]	[140]	[140]
Boundary displaced by 0 miles	1.833	-0.403	-0.294	-0.023	-0.252	-0.353	-0.330
	(0.416)	(0.0864)	(0.0817)	(0.0513)	(0.0723)	(0.119)	(0.0885)
	[179]	[181]	[180]	[181]	[181]	[181]	[181]
Boundary displaced by 50 miles	0.089	-0.136	-0.089	-0.001	-0.095	-0.034	-0.320
	(0.343)	(0.0844)	(0.108)	(0.0605)	(0.0990)	(0.177)	(0.138)
	[144]	[144]	[142]	[143]	[143]	[143]	[143]

Table 3: Results for various subsamples

Outcomes (in natural logarithms):	(1) Nonwhites per county acre	(2) Whites per county acre	(3) Rural population per county acre	(4) Total farm acres per county area	(5) Improved acres per total farm acre	(6) Farm value per county acre	(7) Farm value per total farm acre
Panel A: Subsamples based on closest boundary segment							
Change to PLSS at Free/Slave Boundary	1.834	-0.697	-0.533	0.015	-0.535	-0.529	-0.544
	(0.725)	(0.224)	(0.235)	(0.126)	(0.238)	(0.378)	(0.275)
	[694]	[706]	[706]	[706]	[706]	[706]	[706]
No change to PLSS at Free/Slave Boundary	1.987	-0.573	-0.501	-0.054	-0.290	-0.635	-0.581
	(0.517)	(0.123)	(0.148)	(0.223)	(0.150)	(0.284)	(0.232)
	[586]	[656]	[651]	[650]	[650]	[650]	[650]
Mason-Dixon	1.241	-0.518	-0.427	0.226	-0.215	-0.402	-0.628
	(0.693)	(0.0208)	(0.188)	(0.185)	(0.232)	(0.198)	(0.217)
	[321]	[323]	[318]	[322]	[322]	[322]	[322]
Ohio (the river)	1.384	-0.836	-0.611	-0.069	-0.552	-0.725	-0.656
	(0.855)	(0.260)	(0.284)	(0.148)	(0.287)	(0.459)	(0.321)
	[582]	[590]	[590]	[590]	[590]	[590]	[590]
Missouri (the state)	3.000	-0.519	-0.480	-0.167	-0.425	-0.581	-0.415
	(0.638)	(0.186)	(0.213)	(0.333)	(0.205)	(0.437)	(0.301)
	[377]	[449]	[449]	[444]	[444]	[444]	[444]
Riverine boundaries	1.879	-0.665	-0.519	-0.023	-0.494	-0.646	-0.622
	(0.586)	(0.167)	(0.186)	(0.143)	(0.196)	(0.339)	(0.236)
	[895]	[906]	[905]	[904]	[904]	[904]	[904]
Geometric boundaries	1.910	-0.522	-0.435	-0.003	-0.224	-0.409	-0.407
	(0.658)	(0.188)	(0.245)	(0.288)	(0.134)	(0.234)	(0.188)
	[385]	[456]	[452]	[452]	[452]	[452]	[452]
Closest boundary east of Miami River	1.570	-0.772	-0.607	-0.027	-0.422	-0.640	-0.613
	(0.717)	(0.187)	(0.230)	(0.151)	(0.241)	(0.362)	(0.254)
	[724]	[733]	[728]	[732]	[732]	[732]	[732]
Closest boundary west of Miami River	2.338	-0.494	-0.404	-0.046	-0.410	-0.544	-0.498
	(0.653)	(0.160)	(0.173)	(0.242)	(0.146)	(0.332)	(0.238)
	[556]	[629]	[629]	[624]	[624]	[624]	[624]
Panel B: Subsamples based Newberry data on historical county borders							
FIPS code first appears in or after 1823	2.235	-0.637	-0.534	-0.079	-0.510	-0.595	-0.516
	(0.596)	(0.216)	(0.207)	(0.267)	(0.201)	(0.383)	(0.263)
	[606]	[685]	[684]	[679]	[679]	[679]	[679]
FIPS code first appears before 1823	1.944	-0.588	-0.435	-0.020	-0.314	-0.503	-0.483
	(0.468)	(0.115)	(0.140)	(0.0861)	(0.126)	(0.186)	(0.159)
	[674]	[677]	[673]	[677]	[677]	[677]	[677]
Current boundary first appears in or after 1845	1.352	-1.162	-1.027	-0.420	-0.777	-1.302	-0.882
	(0.666)	(0.244)	(0.263)	(0.317)	(0.176)	(0.380)	(0.247)
	[628]	[704]	[702]	[698]	[698]	[698]	[698]
Current boundary first appears before 1845	2.434	-0.420	-0.274	0.100	-0.112	-0.224	-0.324
	(0.450)	(0.139)	(0.119)	(0.0752)	(0.0856)	(0.173)	(0.147)
	[652]	[658]	[655]	[658]	[658]	[658]	[658]
Panel C: Subsamples based on susceptibility to soil erosion							
More susceptible to erosion (K-factor)	1.876	-0.455	-0.345	-0.004	-0.341	-0.497	-0.492
	(0.485)	(0.114)	(0.101)	(0.0694)	(0.108)	(0.204)	(0.173)
	[659]	[682]	[680]	[679]	[679]	[679]	[679]
Less susceptible to erosion (K-factor)	1.589	-1.127	-0.974	-0.043	-0.570	-0.925	-0.882
	(0.610)	(0.364)	(0.375)	(0.352)	(0.283)	(0.517)	(0.281)
	[621]	[680]	[677]	[677]	[677]	[677]	[677]
More susceptible to erosion (KF-factor)	1.951	-0.475	-0.332	0.061	-0.371	-0.435	-0.496
	(0.507)	(0.111)	(0.116)	(0.111)	(0.113)	(0.252)	(0.172)
	[674]	[682]	[682]	[680]	[680]	[680]	[680]
Less susceptible to erosion (KF-factor)	1.945	-1.131	-1.003	-0.176	-0.606	-1.044	-0.868
	(0.803)	(0.345)	(0.353)	(0.416)	(0.267)	(0.486)	(0.265)
	[606]	[680]	[675]	[676]	[676]	[676]	[676]

Notes:

Table 4: Alternative Approaches to Inference

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcomes (in natural logarithms):	Nonwhites per county acre	Whites per county acre	Rural population per county acre	Total farm acres per county acre	Improved acres per total farm acreage	Farm value per county area	Farm value per total farm acreage
Panel A: Various clusters							
Coefficient	1.899	-0.644	-0.511	-0.0239	-0.405	-0.582	-0.558
Cluster for 15 quantiles of latitude (baseline)	(0.485)	(0.142)	(0.157)	(0.146)	(0.140)	(0.252)	(0.177)
Cluster for 10 quantiles of latitude	(0.546)	(0.142)	(0.159)	(0.118)	(0.153)	(0.252)	(0.186)
Cluster for 5 quantiles of latitude	(0.750)	(0.189)	(0.195)	(0.121)	(0.198)	(0.336)	(0.237)
Cluster for state	(0.731)	(0.338)	(0.327)	(0.282)	(0.143)	(0.395)	(0.212)
No clustering	(0.203)	(0.104)	(0.0935)	(0.0806)	(0.0566)	(0.132)	(0.0831)
Panel B: Conley standard errors, various cutoff distances							
20 Miles	(0.210)	(0.105)	(0.095)	(0.081)	(0.059)	(0.135)	(0.086)
40 Miles	(0.282)	(0.137)	(0.128)	(0.107)	(0.082)	(0.184)	(0.117)
60 Miles	(0.355)	(0.167)	(0.159)	(0.132)	(0.105)	(0.230)	(0.145)
80 Miles	(0.419)	(0.191)	(0.183)	(0.150)	(0.124)	(0.264)	(0.166)
100 Miles	(0.476)	(0.208)	(0.202)	(0.162)	(0.138)	(0.287)	(0.180)
125 Miles	(0.538)	(0.224)	(0.218)	(0.172)	(0.151)	(0.307)	(0.193)
150 Miles	(0.589)	(0.235)	(0.230)	(0.177)	(0.159)	(0.320)	(0.202)
Panel C: Kelly standard errors, various degrees of smoothness (kappa)							
kappa=0.5	(0.432)	(0.150)	(0.112)	(0.082)	(0.143)	(0.214)	(0.197)
kappa=1.5	(0.450)	(0.228)	(0.195)	(0.142)	(0.150)	(0.304)	(0.210)
kappa=4	(0.471)	(0.241)	(0.206)	(0.160)	(0.119)	(0.323)	(0.170)

Notes:

Table 5: Effects at the Boundary: Jumps versus Kinks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcomes (in natural logarithms):	Nonwhites per county acre	Whites per county acre	Rural population per county acre	Total farm acres per county area	Improved acres per total farm acre	Farm value per county acre	Farm value per total farm acre
Panel A: Within 300 miles of boundary (default sample)							
Slavery legal	1.899	-0.644	-0.511	-0.024	-0.405	-0.582	-0.558
	(0.485)	(0.142)	(0.157)	(0.146)	(0.140)	(0.252)	(0.177)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Panel B: Within 450 miles of boundary							
Slavery legal	1.624	-0.692	-0.658	-0.066	-0.588	-0.818	-0.752
	(0.483)	(0.211)	(0.226)	(0.214)	(0.162)	(0.383)	(0.205)
	[1560]	[1667]	[1662]	[1642]	[1642]	[1642]	[1642]
Panel C: Within 600 miles of boundary							
Slavery legal	1.550	-0.938	-0.907	-0.389	-0.613	-1.120	-0.731
	(0.495)	(0.221)	(0.236)	(0.276)	(0.163)	(0.440)	(0.195)
	[1700]	[1811]	[1805]	[1779]	[1779]	[1779]	[1779]
Panel D: Within 900 miles of boundary							
Slavery legal	1.503	-1.263	-1.123	-0.502	-0.568	-1.272	-0.770
	(0.460)	(0.205)	(0.267)	(0.407)	(0.146)	(0.419)	(0.157)
	[1771]	[1889]	[1883]	[1849]	[1849]	[1849]	[1849]
Panel E: Within 300 miles of boundary, intercept and slope shift							
Slavery legal	1.883	-0.641	-0.509	-0.023	-0.405	-0.580	-0.558
	(0.483)	(0.141)	(0.157)	(0.144)	(0.140)	(0.251)	(0.177)
Slavery legal x distance to boundary / 100	-1.024	-1.000	-0.835	-0.494	-0.027	-0.829	-0.336
	(0.661)	(0.511)	(0.524)	(0.509)	(0.203)	(0.673)	(0.298)
	[1280]	[1362]	[1357]	[1356]	[1356]	[1356]	[1356]
Panel F: Within 450 miles of boundary, intercept and slope shift							
Slavery legal	1.616	-0.694	-0.659	-0.060	-0.588	-0.818	-0.758
	(0.479)	(0.212)	(0.225)	(0.210)	(0.161)	(0.380)	(0.203)
Slavery legal x distance to boundary / 100	-0.342	-0.193	-0.081	0.315	0.020	-0.001	-0.316
	(0.478)	(0.386)	(0.425)	(0.532)	(0.167)	(0.677)	(0.200)
	[1560]	[1667]	[1662]	[1642]	[1642]	[1642]	[1642]
Panel G: Within 600 miles of boundary, intercept and slope shift							
Slavery legal	1.554	-0.953	-0.918	-0.396	-0.616	-1.138	-0.742
	(0.489)	(0.215)	(0.237)	(0.268)	(0.162)	(0.427)	(0.190)
Slavery legal x distance to boundary / 100	0.121	-0.792	-0.586	-0.203	-0.099	-0.479	-0.276
	(0.498)	(0.360)	(0.429)	(0.332)	(0.122)	(0.366)	(0.134)
	[1700]	[1811]	[1805]	[1779]	[1779]	[1779]	[1779]
Panel H: Within 900 miles of boundary, intercept and slope shift							
Slavery legal	1.522	-1.345	-1.182	-0.511	-0.597	-1.342	-0.831
	(0.411)	(0.176)	(0.207)	(0.348)	(0.138)	(0.369)	(0.149)
Slavery legal x distance to boundary / 100	0.090	-0.383	-0.271	-0.045	-0.147	-0.345	-0.301
	(0.552)	(0.281)	(0.382)	(0.401)	(0.0995)	(0.382)	(0.144)
	[1771]	[1889]	[1883]	[1849]	[1849]	[1849]	[1849]

Notes:

Table 6. Accounting for the Gap: Improvement and Total Factor Productivity

	(1)	(2)	(3)	(4)	(5)	(6)
	Farm land per farm acre			Agriculture	Total Factor Productivity	
	Land excluding buildings	Improved Land 2x Method	Subtraction Method	Weiss Labor	Lebergott Labor	Improved Land 2X
Panel A: Outcome in Natural Logs						
300-mile buffer	-0.46	-0.36	-0.48	-0.10	-0.12	-0.08
	(0.174)	(0.147)	(0.346)	(0.0360)	(0.0358)	(0.0375)
	[1355]	[1355]	[1286]	[1351]	[1351]	[1351]
150-mile buffer	-0.26	-0.19	-0.21	-0.03	-0.05	-0.02
	(0.101)	(0.0897)	(0.162)	(0.0470)	(0.0463)	(0.0462)
	[820]	[820]	[795]	[817]	[817]	[817]
Border counties	-0.25	-0.181	-0.21	-0.07	-0.09	-0.06
	(0.0860)	(0.0793)	(0.134)	(0.0367)	(0.0348)	(0.0363)
	[142]	[142]	[141]	[142]	[142]	[142]
Panel B: Outcome in Levels						
300-mile buffer	-7.74	-4.20	-6.11	-0.09	-0.12	-0.07
	(3.214)	(1.844)	(3.352)	(0.0415)	(0.0446)	(0.0449)
	[1355]	[1355]	[1354]	[1351]	[1351]	[1351]
150-mile buffer	-5.03	-2.46	-3.52	-0.03	-0.05	-0.02
	(2.210)	(1.246)	(1.957)	(0.0526)	(0.0537)	(0.0533)
	[820]	[820]	[819]	[817]	[817]	[817]
Border counties	-4.90	-2.28	-3.33	-0.06	-0.08	-0.04
	(2.36)	(1.388)	(2.328)	(0.0322)	(0.0313)	(0.0314)
	[142]	[142]	[141]	[142]	[142]	[142]

Notes:

Table 7. Distribution of Population, Households, and Wealth in 1850 Sample by Real Estate and Slave Wealth

Status			Population Percentages				Appreciation	Population Percentages			
	Real Estate	Slave Wealth	Total Pop	Free Pop	Wealth Holder	Slave Holder	'Clay' Threshold	House-hold	Real Estate	Slave Wealth	All Wealth
Enslaved	0	-	24.38				Always				
Free Pop	0	0	29.67	39.24			~	44.82	0.00	0.00	0.00
Free Pop	+	0	26.98	35.68	58.72		0	31.91	13.36	0.00	8.75
RE vs SW	10 times	+	0.79	1.05	1.72	4.17	10.0%	0.86	14.30	1.39	9.85
"	9	+	0.14	0.19	0.31	0.76	11.1%	0.17	1.50	0.30	1.08
"	8	+	0.14	0.19	0.31	0.76	12.5%	0.17	1.90	0.43	1.39
"	7	+	0.16	0.21	0.35	0.84	14.3%	0.20	2.32	0.59	1.73
"	6	+	0.26	0.35	0.57	1.39	16.7%	0.29	2.99	0.89	2.26
"	5	+	0.34	0.44	0.73	1.77	20.0%	0.44	3.98	1.37	3.08
"	4	+	0.87	1.15	1.89	4.57	25.0%	0.87	5.94	2.56	4.78
"	3	+	1.07	1.41	2.32	5.62	33.3%	1.23	8.82	4.80	7.43
"	2	+	1.96	2.59	4.27	10.33	50.0%	2.23	12.42	9.68	11.47
"	1	+	3.76	4.97	8.18	19.82	100.0%	4.56	17.25	23.78	19.50
"	Less than	+	6.00	7.94	13.07	31.65		7.72	15.22	53.07	28.27
"	0	+	3.48	4.60	7.57	18.33		4.53	0.00	1.15	0.40

Notes:

Notes for Table 7:

The sample covers 8,615 households on the slave side of the 300-mile buffer region (Menard et al. 2004, Ruggles et al. 2021b. These include 15,359 enslaved and 47,614 free persons. Total Real Estate equaled $8,207k; Total Slave Wealth equaled $4,322k. The real estate wealth comes directly from census; slave wealth is based on holdings (enumerated by gender and age) reported in the census multiplied by 1850 prices, distinguished by demographic characteristics, for the Old South as reported in Carter et al. 2006, Series Bb215-216.

The table calculates the distribution of population, households, and wealth-holdings by household status. The status breakdowns for the population include the enslaved, free persons in households without real estate or slaves; free persons in households with real estate but without slaves; free persons in households with both real estate and slaves; and finally free persons in households with slaves but without real estate. Among the free persons in households with both real estate and slaves, status is further distinguished based on whether their real estate holdings are with integer multiples of their slave holdings.

The values in the "Clay Threshold" column indicate the rate of real estate appreciation required under a policy of uncompensated emancipation for the gains in real estate wealth to exceed the (complete) losses in slave wealth. The threshold is simply the inverse of the real estate to slave wealth ratio. Under a compensated or gradual emancipation schemes (permitting sale for export), the threshold would be reduced in proportion to fraction of slave wealth recovered.

Appendix A: Land Values and the Scarcity of a Variable Factor

A.1. The Basic Problem and a First-Order Solution:

How does the price of the fixed input (e.g., land) respond to a change in price of a variable input (e.g., a type of labor)? To fix ideas, let inputs $x_i, i \in \{2 \dots k\}$, be supplied perfectly elastically at fixed prices p_i. In contrast, input $i = 1$ is in fixed supply locally and has endogenous price p_1. Inputs are defined to be positive: $x_i \geq 0 \ \forall \ i$.

Assume that factor markets are perfectly competitive, including the land market. This implies zero profits in equilibrium. One could equivalently adopt a 'Ricardian' approach: land owners earn the residual (rent) once other factors have been paid. If there is an open market for land, then land rents at a location should be capitalized into the price of land. Therefore, profits earned on variable factors should equal the opportunity cost of land.

In response to a parameter change, the variable factors adjust, as does the price of the fixed factor. Let $\mathrm{d}p_2 > 0$ be given. What is $\mathrm{d}p_1$? Consider the profit function for a particular location: $\pi(\vec{p})$. This gives the maximum profits attainable for a given price vector. Taking full differentials of $\pi = 0$ yields

$$\pi_1 \mathrm{d}p_1 + \pi_2 \mathrm{d}p_2 = 0, \qquad (*)$$

which gives the following equilibrium relationship:

$$\frac{\mathrm{d}p_1}{\mathrm{d}p_2} = -\frac{\pi_2}{\pi_1}$$

Recall Hotelling's Lemma: the derivative of the profit function w.r.t. p_i is factor demand $-x_i$. Therefore $\frac{\mathrm{d}p_1}{\mathrm{d}p_2} = -\frac{x_2}{x_1}$, which is negative (strictly so if $x_2 > 0$). In terms of elasticities,

$$\epsilon_{12} \equiv \frac{p_2}{p_1}\frac{\mathrm{d}p_1}{\mathrm{d}p_2} = -\frac{p_2 x_2}{p_1 x_1},$$

the negative ratio of the expenditure shares.

It is intuitive that the prices are related in this way. When p_2 changes, it affects the net worth of the firm. The firm/farm's net worth shrinks more if the expenditure share on x_2 is large. This decline in net worth is spread more widely if the expenditure share on x_1 is itself large.

A.2. Discussion of Returns to Scale:

We did not state an assumption above about returns to scale. Nevertheless, this is implicit in invoking perfect competition. An assumption of a finite solution is inconsistent with simultaneously being a price taker and facing increasing returns to scale. So perhaps we should assume non-increasing returns. Further, a typical counterargument to a claim of decreasing returns to scale (DRS) is that instead there is some unspecified input (e.g., proprietor's labor). If we could properly catalog and duplicate all inputs, then this cloned set of factors would generate just as much output as the original. This analysis suggests that the leading case is constant returns to scale (CRS). Under constant returns, Euler's Theorem tells us that, if prices equal marginal revenue products, then the sum of factor payments equals total output. This implies that the land rent that we calculate as a residual also equals the price that would prevail in a competitive market for land.

If the production function does exhibit DRS, then Euler's theorem tells us that the residual rent would be different from the marginal product of land. What would equilibrium in the land market look like in this case? DRS also has the unrealistic implication that production units should be infinitesimally small. It is likely, however, that some indivisibility (e.g., farm operators coming in integer units) would prohibit farm units from being below some minimum scale. If so, the farm size would be constrained and therefore the optimal choice of land would not be determined by the first order condition. The market value of farms at this minimum scale would instead be pinned down by the profit (the residual implied by Euler's Theorem).

A.3. The example of Cobb-Douglas with constant returns:

Assumptions are as above, except that output is determined by a Cobb-Douglas with constant returns to scale (CRS). The ith factor has share $\alpha_i \in (0,1)$. The FOCs define the relative factor inputs, e.g.,

$$\frac{p_1 x_1}{\alpha_1} = \frac{p_i x_i}{\alpha_i} \;\; \forall \, i = 1, \dots, k.$$

As the first factor is fixed in size, we can define the others in terms of x_1:

$$x_i = \frac{p_1}{p_i} \frac{\alpha_i}{\alpha_1} x_1$$

The price of output is the numeraire. Output (Y) and cost (C) are as follows:

$$Y \equiv \prod_{i=1}^{k} x_i^{\alpha_i} = \prod_{i=1}^{k} \left(\frac{p_1}{p_i} \frac{\alpha_i}{\alpha_1} x_1 \right)^{\alpha_i} = \frac{p_1 x_1}{\alpha_1} \prod_{i=1}^{k} \left(\frac{\alpha_i}{p_i} \right)^{\alpha_i}$$

$$C \equiv \sum_{i=1}^{k} p_i \, x_i = \sum_{i=1}^{k} p_i \left(\frac{p_1}{p_i} \frac{\alpha_i}{\alpha_1} x_1 \right) = \frac{p_1 x_1}{\alpha_1} \sum_{i=1}^{k} \alpha_i$$

Per the CRS assumption, $\sum_{i=1}^{k} \alpha_i = 1$, so $C = p_1 x_1 / \alpha_1$. Profit is as follows:

$$\pi = Y - C = \frac{p_1 x_1}{\alpha_1} \left(\prod_{i=1}^{k} \left(\frac{\alpha_i}{p_i} \right)^{\alpha_i} - 1 \right)$$

Competitive markets for factors imply a zero-profit condition: $\pi = 0$, or $\prod_{i=1}^{k} (\alpha_i / p_i)^{\alpha_i} = 1$, or

$$p_1 = \alpha_1 \prod_{i=2}^{k} \left(\frac{\alpha_i}{p_i}\right)^{\frac{\alpha_i}{\alpha_1}}$$

This yields an elasticity equal to the (negative of the) ratio of the factor shares, as in the generic version above. (Take logs of both sides to see this.) For Cobb-Douglas, however, this is not an approximation, but rather an elasticity that holds globally, in logs, at any interior solution.[1]

We could also derive this price and elasticity from optimal land use (i.e., the demand curve for land as a productive factor). The FOC is

$$\begin{aligned} p_1 &= \alpha_1 Y / x_1 \\ p_1 &= \frac{\alpha_1}{x_1}\left(\frac{p_1 x_1}{\alpha_1} \prod_{i=1}^{k} \left(\frac{\alpha_i}{p_i}\right)^{\alpha_i}\right) \\ p_1 &= \alpha_1 \prod_{i=2}^{k} \left(\frac{\alpha_i}{p_i}\right)^{\frac{\alpha_i}{\alpha_1}} \end{aligned}$$

which is the same as the price derived from the zero-profit condition. This is as predicted by Euler's Theorem.

A.4. Second-order effects:

Why does the general elasticity not depend on the extent of substitution between factors? Hotelling's Lemma is a first-order result that follows an application of the Envelope Theorem. A small change in price will occasion a set of small quantity changes. But the effect on profits of small quantity changes is approximately zero near the optimum, which is where the profit function is evaluated.

Accordingly, the dependence on factor substitutability only appears when considering second-order changes. The first derivative, $\mathrm{d}p_1/\mathrm{d}p_2$ is negative, so that the increase in p_2 decreases p_1. Does the second derivative amplify this effect, $\frac{\mathrm{d}^2 p_1}{\mathrm{d}p_2^2} < 0$, or attenuate it?

The zero-profit condition ($\pi(\vec{p}) = 0$) still holds, even for large changes, because p_1 adjusts to absorb any surplus generated by the other factors. Taking full differentials of the zero-profit conditions to first and second order yields the following equations:

$$[\nabla\pi(\vec{p})]\overrightarrow{\mathrm{d}p} = 0\ ;\ \overrightarrow{\mathrm{d}p}'[\nabla^2\pi(\vec{p})]\overrightarrow{\mathrm{d}p} = 0$$

[1] Under CRS, the zero-profit condition can be re-written as $\vec{\alpha} \cdot [\log(\vec{p}) - \log(\vec{\alpha})] = 0$. One set of prices consistent with an interior solution is $\vec{p} = \vec{\alpha}$. To stay in the zero-profit set, a deviation of some price p_i from this vector has to be matched by offsetting proportional deviations in other prices, with the elasticities defined by the relative factor shares.

where $\overrightarrow{\mathrm{d}p} = [\ \mathrm{d}p_1\ \mathrm{d}p_2\ 0 \ldots\ 0\ ]'$ and ∇ is the operator that takes derivatives w.r.t. the price vector $\vec{p}$. The first-order equation reproduces equation $(*)$ from above. The second-order equation has a matrix pre- and post-multiplied by the infinitesimal-change-in-price vector:

$$[\ \mathrm{d}p_1\ \mathrm{d}p_2\ 0\ \cdots\ 0\ ]\begin{bmatrix} \pi_{11} & \pi_{12} & \pi_{13} & \cdots & \pi_{1k} \\ \pi_{21} & \pi_{22} & \pi_{23} & \cdots & \pi_{2k} \\ \pi_{31} & \pi_{32} & \pi_{33} & \cdots & \pi_{3k} \\ \pi_{41} & \pi_{42} & \pi_{43} & \cdots & \pi_{4k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \pi_{k1} & \pi_{k2} & \pi_{k3} & \cdots & \pi_{kk} \end{bmatrix}\begin{bmatrix} \mathrm{d}p_1 \\ \mathrm{d}p_2 \\ 0 \\ \vdots \\ 0 \end{bmatrix} = 0$$

Turn the crank once:

$$[\ \mathrm{d}p_1\ \mathrm{d}p_2\ 0\ \cdots\ 0\ ]\begin{bmatrix} \mathrm{d}p_1 \sum_{i=1}^{k} \pi_{i1} \\ \mathrm{d}p_2 \sum_{i=1}^{k} \pi_{i2} \\ 0 \\ \vdots \\ 0 \end{bmatrix} = 0$$

Turn the crank again:

$$(\mathrm{d}p_1)^2 \sum_{i=1}^{k} \pi_{i1} + (\mathrm{d}p_2)^2 \sum_{i=1}^{k} \pi_{i2} = 0$$

which gives us

$$\frac{\mathrm{d}^2 p_1}{\mathrm{d}p_2^2} = -\left(\sum_{i=1}^{k} \pi_{i2}\right) \Big/ \left(\sum_{i=1}^{k} \pi_{i1}\right) \qquad (\dagger)$$

The second derivative is negative if the two sums have the same sign. Do they? Recall that the profit function has a Hessian ($\mathbf{H} \equiv \nabla^2 \pi$) that is negative semi-definite.[2] Therefore, for any non-zero vector w,

$$w'\mathbf{H}w \leq 0. \qquad (\ddagger)$$

Consider the two vectors $w_1 = [\ 1\ 0\ 0\ \cdots\ 0\ ]'$ and $w_2 = [\ 0\ 1\ 0\ \cdots\ 0\ ]'$. Notice that using w_i in the inequality (‡) constructs the ith column sum. This allows us to rewrite equation (†) as follows:

[2] Inputs were defined positively above. If we had defined a net-output vector instead, the Hessian would be positive semi-definite. What matters is the ratio (left-hand side of (†), in which this sign convention cancels out.

$$\frac{\mathrm{d}^2 p_1}{\mathrm{d}p_2^2} = -\frac{w_2{}'\mathbf{H}w_2}{w_1{}'\mathbf{H}w_1},$$

which, by (‡), is weakly negative (strictly so, as long as $w_2{}'\mathbf{H}w_2$ is not zero).

Because the second derivative (of p_1 w.r.t. p_2) is negative, allowing for substitution among the x_i when $p_2 \uparrow$ amplifies the reduction in p_1, as compared to the first-order effect. Intuitively, there are contrasting parts of the second-order effect of $p_2 \uparrow$. If the first two inputs are substitutes, the decrease in x_2 shifts out the demand for x_1, *ceteris paribus*. But the decline in profits also spurs the flight of other mobile factors from the area. This latter effect dominates the former one for any interior solution at which we can take derivatives.

A.5. The case of perfect substitutes:

Here substitutability is cranked up to the max, and the relevant functions are not differentiable at an interior solution. If all factors are perfect substitutes, then we can write output as $Y = \sum_{i=1}^{k} \alpha_i \, x_i$. This case is, in fact, quite uncomplicated. The price of land is independent of the other factors. The marginal product of x_1 is α_1, which determines the price p_1. The effect of other factor prices on p_1 is nil. We have to careful with this case, though, because it is easy to scale up in spite of a fixed supply of land. If any of the other factors, $i > 1$, have $p_i < \alpha_i$, then one could increase those factors and increase profits. The fixed factor is in no way a constraint to unlimited growth.

Appendix B: Definition of Free/Slave Boundary and Spatial Extent of Data

We use standard definitions of the U.S. states where slavery was legal in 1860. This excludes territories, e.g. Kansas and Nebraska. We classify as 'free' those states, e.g. New Jersey and Illinois, where general emancipation had taken place well before 1860, but there remained some former slaves bonded under transitional indentureship, for example. This gives the following 'slave' states: Alabama, Arkansas, Delaware, the District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas, and Virginia. This set of states gives a clearly defined border that separates the country into two sections, one slave and one free. The resulting free/slave boundary is defined, from west to east, as follows:

- The Missouri/Iowa border
- The Missouri/Illinois border, which largely follows the Mississippi River down to Cairo, Illinois
- The northern border of Kentucky from Cairo, Illinois, to Ashland, Kentucky, which follows the Ohio River
- The northern border of (West) Virginia, along the Ohio River
- The western border of Pennsylvania with the northern (West) Virginia panhandle
- The southern border of Pennsylvania with (West) Virginia and Maryland, which follows the Mason-Dixon Line
- The Delaware/Pennsylvania border
- The midline of the Delaware River, between New Jersey and contiguous Delaware

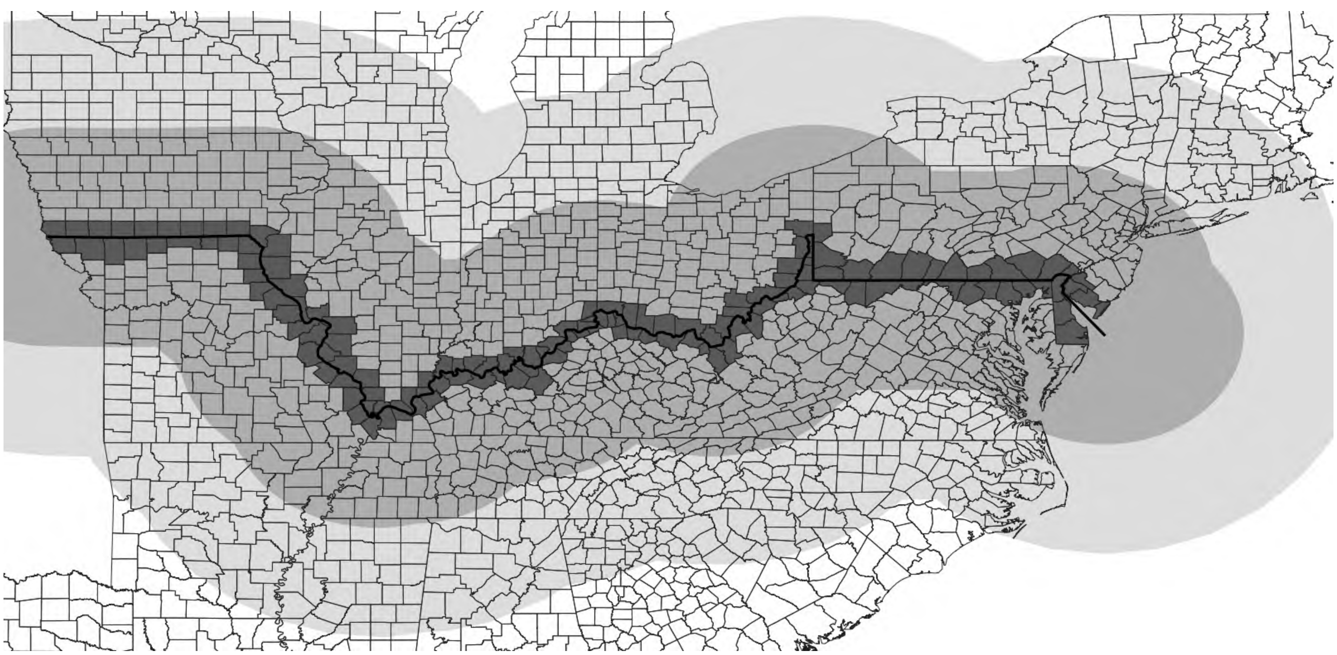
We use spatial data from the NHGIS project (Minnesota Population Center, 2011) to map the free/slave boundary and to measure counties' proximity to said boundary. We present this boundary in Figure 1 of the paper and here in Appendix Figure A.1. To this map, we add the 1860 county boundaries, per NHGIS, for reference. In the paper, we use two distinct concepts of proximity: adjacency and distance. Adjacency refers to a county directly touching the free/slave boundary. For example, the 1860 counties that are adjacent to the free/slave boundary are shown with dark-gray shading. (The proximity measures are computed separately for each year of data.) We also construct a buffer of 150 and 300 miles from the boundary. Counties adjacent to the boundary fall within these two buffers. Additional areas within the 150-mile buffer are shaded in medium gray in Appendix Figure A.1. In addition to those two, areas within 300 miles are shaded in light gray. Counties with any portion lying within these buffers are categorized in the relevant buffer zones. As a control variable, we also compute the distance from the border for each county's centroid and the *average* distance of a county to the free/slave border by computing distance to the boundary for a high-dimensional (10kx10k) raster over the contiguous US and then by calculating the average value within each county. As another control, we use the latitude and longitude of each county's centroid, as supplied by NHGIS.

The presence of riverine boundaries necessitates further discussion. Boundaries on rivers are typically defined on a specific side of a river, or perhaps at a midpoint. Changes in the course of a river over time or poor surveying at the time of setting the border might generate discrepancies between a boundary and the current course of a river, even to the point of generating exclaves. For example, Kaskaskia is an exclave of Illinois created by a change in the course of the Mississippi River. We rely not on the contemporary river course, but rather the NHGIS definition of the historical (1860) boundary to set state borders. For the most part, the rivers are sufficiently narrow and their historical meanders sufficiently small so as to make little difference for our classification of counties with respect to the free/slave boundary. Counties that are adjacent to an above-named river segment will be adjacent to the free/slave border as well, for example. The major exception is the Delaware River, which turns into a bay between Delaware and New Jersey. The statutory boundary between New Jersey and Delaware lies on the New Jersey side of the Delaware River, except for a small exclave of Delaware on the New Jersey side. We choose the midpoint of the river instead to better calibrate the measure of distance to the boundary. This does not change the adjacency concept for counties on either side of the Delaware River, but it brings the distance measurement into better balance between sides of the river.

References

Minnesota Population Center. National Historical Geographic Information System: Version 2.0. Minneapolis, MN: University of Minnesota 2011.

Appendix Figure B.1: The 1860 Free/Slave Boundary and Several Measures of Proximity



Notes: this map displays 1860 county boundaries (thin black lines), the free/slave boundary (thick black line), and three measures of proximity to said boundary. The counties that touch the free/slave boundary are shaded in dark gray. Additional areas that lie within a buffer of 150 miles from the boundary have medium gray shade. Further areas within a buffer of 300 miles from the free/slave boundary are denoted with a light gray shade.

Appendix C: Soil Characteristics

Soil variables are drawn from Miller and White (1998), who base their data on information from the U.S. Department of Agriculture's STATSGO soil database. We use the numerical variables (e.g. fraction of the soil that is sand or soil pH) in their database. The data come as spatial raster files. These files and the quotes below are from the web site that accompanies Miller and White: http://www.soilinfo.psu.edu/, accessed December 17, 2020.

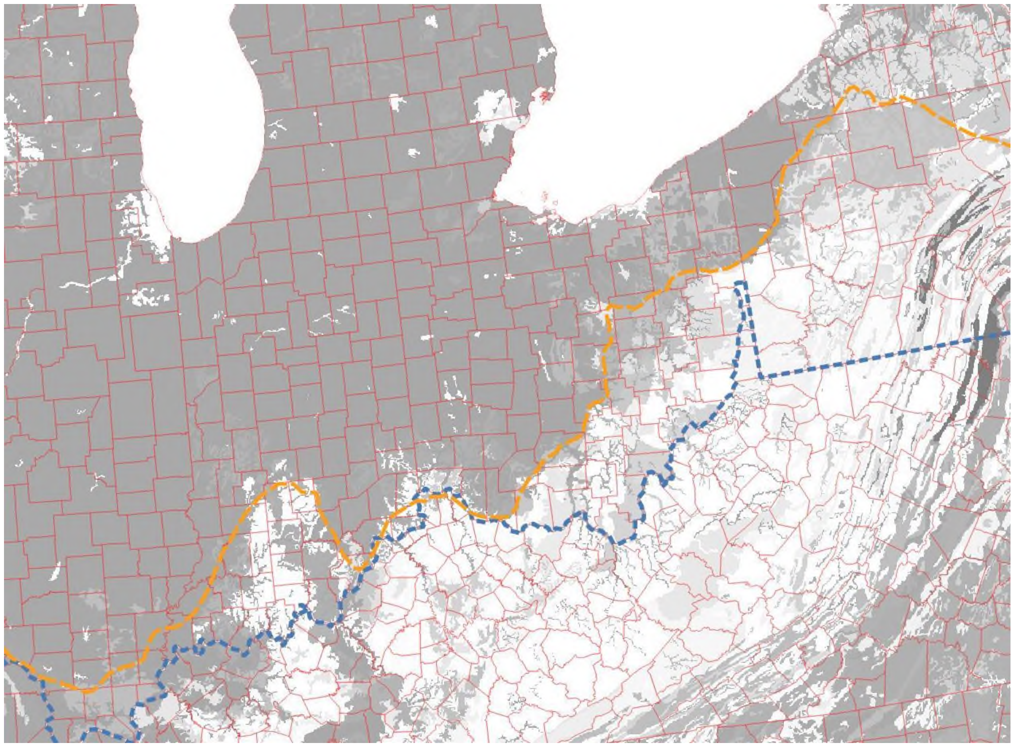
Variables are defined as follows:

- Available water capacity: water volume available to plants if the soil is at capacity. "The mean available water capacity for each STATSGO map unit was computed for three column lengths, 100, 150, and 250 cm, measured from the surface."
- Bulk density: ratio of the mass of the moist soil to its total volume.
- Fractions of clay, sand, and silt. Continuous variables built from underlying information about discrete soil types in USDA's STATSGO.
- k−factor: "a relative index of susceptibility of bare, cultivated soil to particle detachment and transport by rainfall."
- pH: measure of the acidity or alkalinity of the soil.
- Porosity: "a measure of the volume of air and water-filled pores in the soil," computed from bulk density and particle density.
- Depth to bedrock: distance from surface to bedrock. This measure is effectively top-coded at 60 inches.

The following variables are defined for the eleven soil layers: bulk density, fractions of {clay, sand, silt}, porosity, and pH. Soil layers, in inches from the surface, are as follows: 0-2, 2-4, 4-8, 8-12 12-16, 16-24, 24-31, 31-39, 39-59, 59-79, 79-98.

Appendix Figure C.1 provides an example of these data in relation to the free-slave boundary and to the terminal moraine. We display the depth to bedrock, with a darker color indicating more soil on top of bedrock. We zoom in to the neighborhood of the Ohio River, as this is where the terminal moraine (maximum glacial extent) and free-slave boundary are most coincident. These boundaries are displayed on the map, as are 1860 county boundaries. The relationship between soil depth and the glacier’s footprint is evident in the map. Areas north of the terminal moraine have deeper soil and this seems to be a function of the glacial extent and not of some smooth spatial trend. It is also apparent that the some-time coincidence of a change in depth and change in slavery legal status is more plausibly related to the glacial rather than institutional history.

Appendix Figure C.1: Depth to Bedrock in the Neighborhood of the Ohio River



Notes: this map uses gray shading to denote the depth of soil above bedrock, according to the Miller & White (1998) database. The orange line with long dashes shows the terminal moraine, the blue line with short dashes shows the free-slave boundary, and the thin red lines display the 1860 county boundaries. (See Appendices B and D for further information on these boundaries.)

Appendix D: Measurement of Glacial Extent

We digitized the location of the terminal moraine using maps published by George Frederick Wright (1884, 1890, 1892). This geological feature is a "well defined southern limit to the marks of glacial action in the United States" (Wright, 1884, page 203). We worked with the most detailed maps provided for each mapping segment. We also used the NHGIS files for 1860-1890 to help georeference points on Wright's maps.

Going from east to west, segments within a given area were digitized using the indicated maps.

- Massachusetts and New York: Wright, 1884, Plate 1 and text on page 203.
- New Jersey: Wright, 1884, plate 2.
- Pennsylvania: Wright, 1884, plate 3.
- Ohio: Wright, 1884, Plates 8 through 16.
- Kentucky: Wright, 1884, Plates 5, 16 and 17. The latter two plates were more detailed, but only covered the Cincinnati area. Plate 5 was used for the area around Madison, Indiana.
- Indiana: Wright, 1890, Figure 3.
- Illinois: Wright, 1890, Plate 5.
- Driftless region: Wright, 1892, unnumbered map, facing page 68.
- Missouri: Wright, 1892, text on page 96 and unnumbered map facing page 68.

Appendix Figure D.1 displays the terminal moraine (glacial boundary) as a dashed line. For comparison, the free/slave boundary is shown as a thick, solid line, and contemporary state boundaries are displayed as thin, black lines. In general terms, the glacial and free/slave boundaries are both oriented in an east/west direction, but they do not precisely coincide. The southern extent of the glacier is to the north of the free/slave boundary, with three exceptions. The greatest exception is in the state of Missouri, which is approximately split in half by the terminal moraine. This moraine crosses the Mississippi river near St. Louis, and generally follows the course of the Missouri River and then the Osage River. Somewhat downriver of St. Louis, the moraine is close to the Mississippi River, but stays on the Illinois side. (Of the areas with greatest slaveholding in Missouri, the 'Little Dixie' region is largely in the glaciated region, while the 'Bootheel' region is not at all.) The terminal moraine also cuts into Kentucky for a short stretch across the river from Madison, Indiana, and for a longer stretch across the river from Cincinnati, Ohio. (See Appendix Figure D.2, Panel A, for detail.) Away from these areas, the southernmost glacial extent cuts a path significantly to the north of the free/slave border. Apart from those noted above, the closest approach of the terminal moraine to the free/slave boundary is at the Wabash River and at the northern panhandle of West Virginia. (See Appendix Figure D.2, Panel B, for example.)

In some areas, the terminal moraine is superficially noteworthy as a ridge. In others, it is less noticeable to a casual, surface observer. In all areas, however, the extent of the glacier can be determined by the presence or absence of rock striations and glacial till, and other features well understood by geologists.

We also digitized the location of the 'Driftless Region,' an area north of the terminal moraine that was nevertheless not subject to glaciation. It is mostly found in Southwest Wisconsin. (See Appendix Figure D.2, Panel C, and note the rotation of the map, such that north points right.)

References

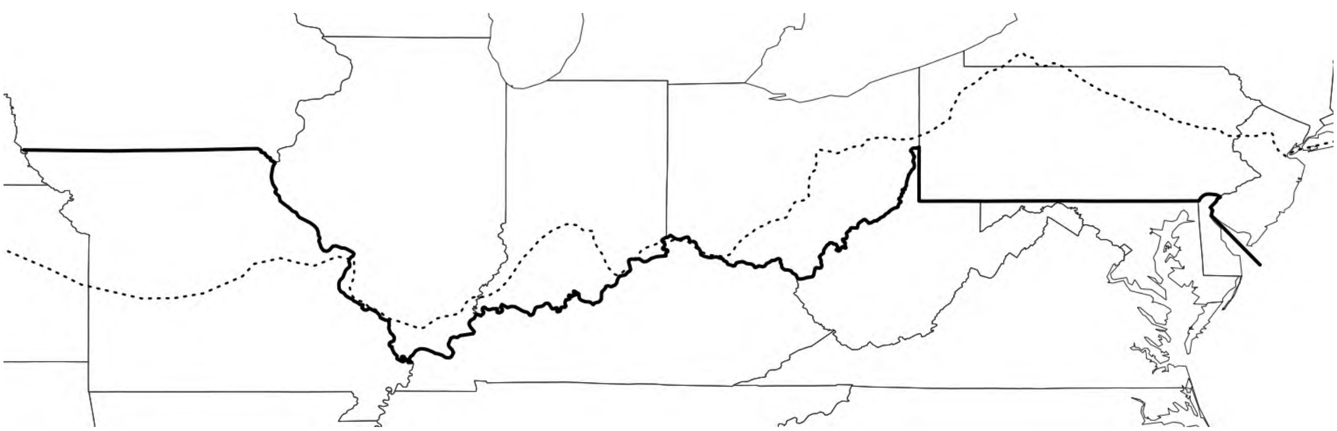
Minnesota Population Center. National Historical Geographic Information System: Version 2.0. Minneapolis, MN: University of Minnesota 2011.

Wright, G. Frederick (1884). The glacial boundary in Ohio, Indiana and Kentucky. Cleveland, Ohio: Western Reserve Historical Society.

Wright, G. Frederick (1890). The glacial boundary in western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois. Bulletin of the United States Geological Survey No. 58. Washington, D.C.: Department of the Interior, United States Geological Survey.

Wright, G. Frederick (1892). Man and the glacial period. Akron, Ohio: The Werner Company.

Appendix Figure D.1: Terminal Moraine, as compared to Free/Slave Boundary and State Borders

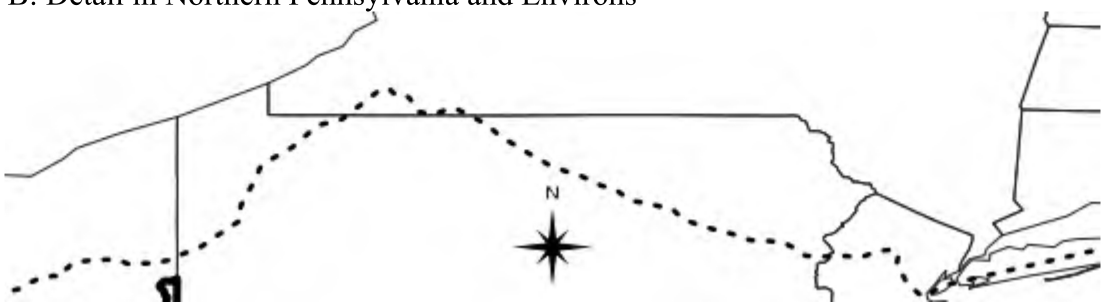


Sources: NHGIS (2011) for state boundaries, plus authors' calculations for free/slave boundary; Wright (1884, 1890, 1896) for terminal moraine, plus authors' digitization. See text of Appendix D for detailed sources.

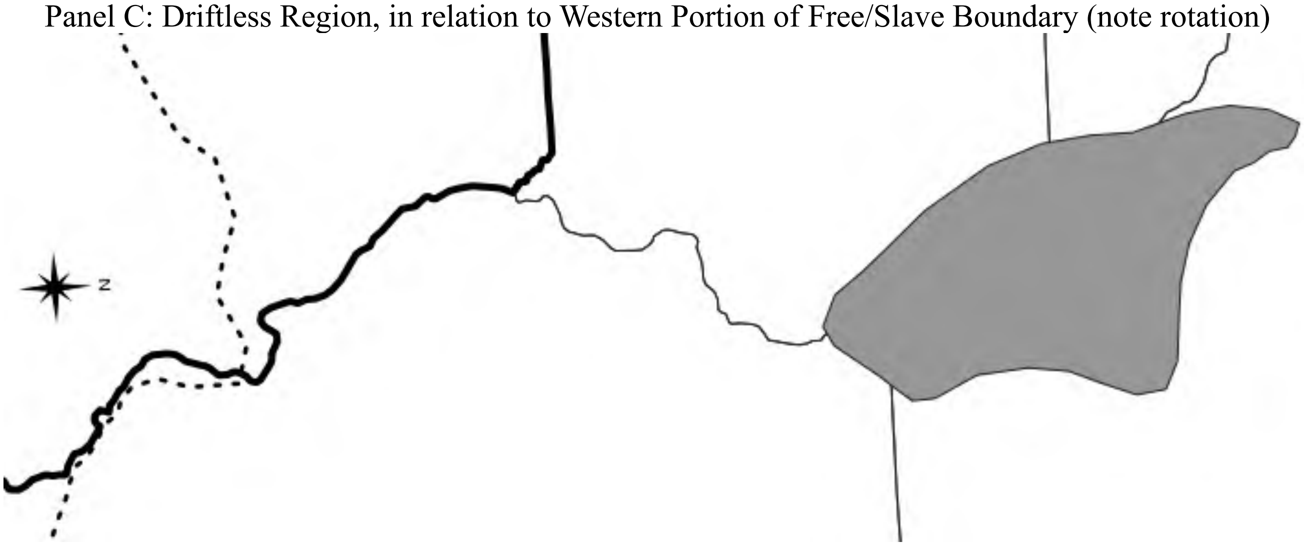
Appendix Figure D.2: Three Close-up Views of Terminal Moraine

Panel A: Crossing Points into Kentucky and Missouri

Panel B: Detail in Northern Pennsylvania and Environs



Panel C: Driftless Region, in relation to Western Portion of Free/Slave Boundary (note rotation)



Notes: see note for Appendix Figure D.1. The Driftless Region is graded in gray in Panel C.

Appendix E: Type of Land Survey

We construct two measures of the original land survey, as described in this appendix. Our principal focus is on whether or not the land was in the public land survey system (PLSS). The PLSS is a rectilinear grid. The grid defines six-mile square townships, which are subdivided into 36 square sections each, and further subdivided into half sections, quarter sections, etc. There are numerous deviations from a perfect grid where natural features or preceding claims or grants intervene. Much of the Northwest Territories was surveyed and demarcated using the PLSS. (Notably, significant sections of Southern Ohio were not included in the PLSS.) In contrast, a large fraction of the Upper South was demarcated using metes and bounds. There is a smattering of other systems in the sample as well, such as several colonial land claims that predate incorporation of such land into the United States.

The underlying data are in a shapefile produced by the US Geological Survey (2010). We use this file to produce two distinct variables in the 1860 county data.

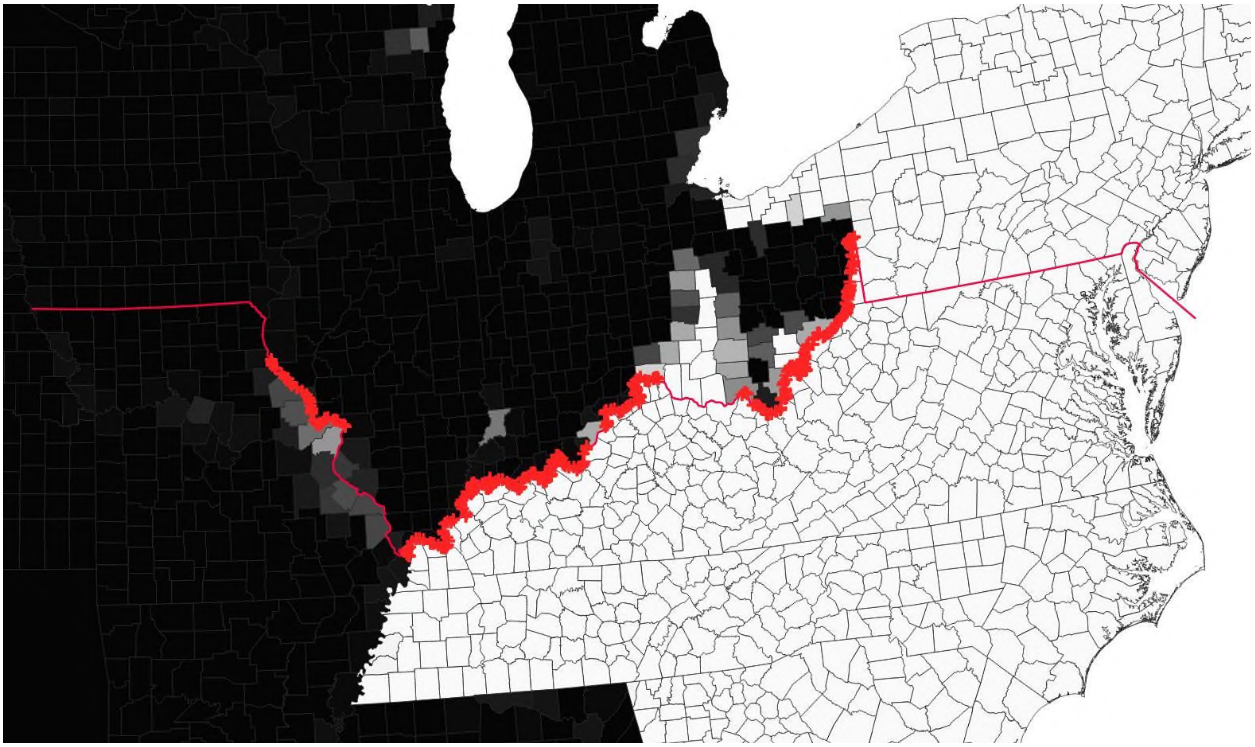
1. What fraction of the 1860 County was covered by the PLSS? We construct the high-dimensional raster coded as a binary variable indicating the presence of the PLSS in a given pixel of the raster. We then take an average of these pixels within each 1860 County. The distribution of the resulting variable is highly bimodal. The vast majority (91%) of counties have either less than 5% or more than 95% of the land area in the PLSS.

2. Is the free-slave border segment nearest to a given county associated with the change in land survey to or from the PLSS? We took our constructed shape file for the free-slave boundary and split it into nodes, each of which we coded according to whether there was a change in land survey system at that point. For most of the boundary, there are large stretches over which this coding is clear and constant. For example, the Missouri/Iowa border sees no change, because both states are on the PLSS in that neighborhood. Similarly, no point on the Mason-Dixon line is associated with a change, as the adjoining states predate the PLSS. Almost all of the Ohio River is associated with a change, with Kentucky and Virginia being principally metes and bounds and the Old Northwest being almost exclusively under PLSS. There are a few exceptions, however. There are several land allocations north of the Ohio River that predate the PLSS, such as Ohio's Virginia Military District, which was allocated using metes and bounds. (A comparison of this area with the rest of the state of Ohio figures prominently in the work by Libecap and Leuck, 2011.) The most complicated boundary is between Missouri and Illinois, where there were colonial land claims (French and Spanish) that predate the PLSS. Near St. Louis, these claims are almost entirely on the Missouri side, and thus the free-slave boundary is associated with a change in survey system. Farther downriver, however, such claims tend to be either on both or on neither side of the river, and therefore not reflecting a change in survey system. (Because we are using this variable to split the sample, we use a broad-brushstroke coding of the boundary rather than a hyper-local one. This gives us stretches of the border as described.)

References:

U.S. Geological Survey (USGS), 2010. Public Land Survey System of the United States. Reston, VA: USGS. Accessed from http://nationalatlas.gov/atlasftp.html, December 2, 2010.

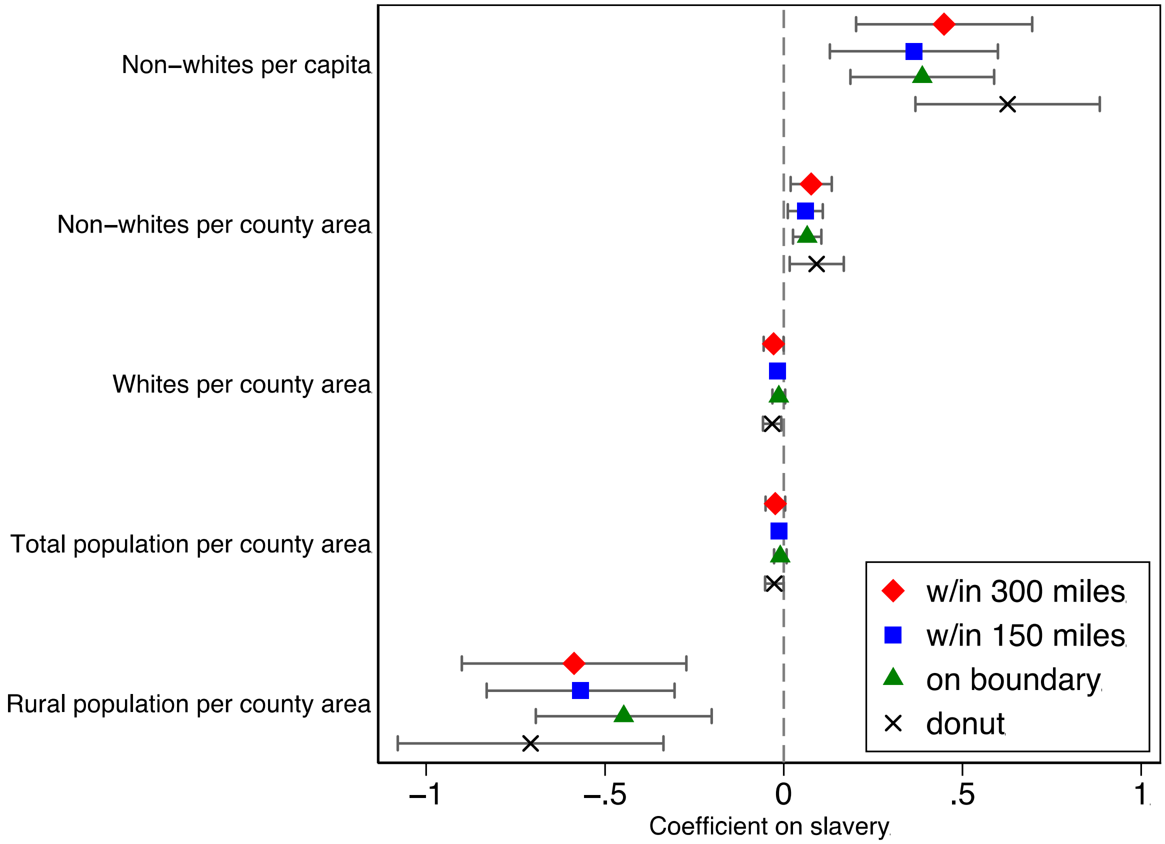
Appendix Figure E.1: Coverage of PLSS and Change to PLSS at Free-Slave Boundary



Notes: this map displays 1860 counties shaded by the fraction of land in the PLSS. The free-slave boundary is a solid red line. Additional cross-hatching is present when there is a change between a PLSS and a non-PLSS system at this boundary. PLSS status is measured using USGS (2010). Other features are described in Appendix B.

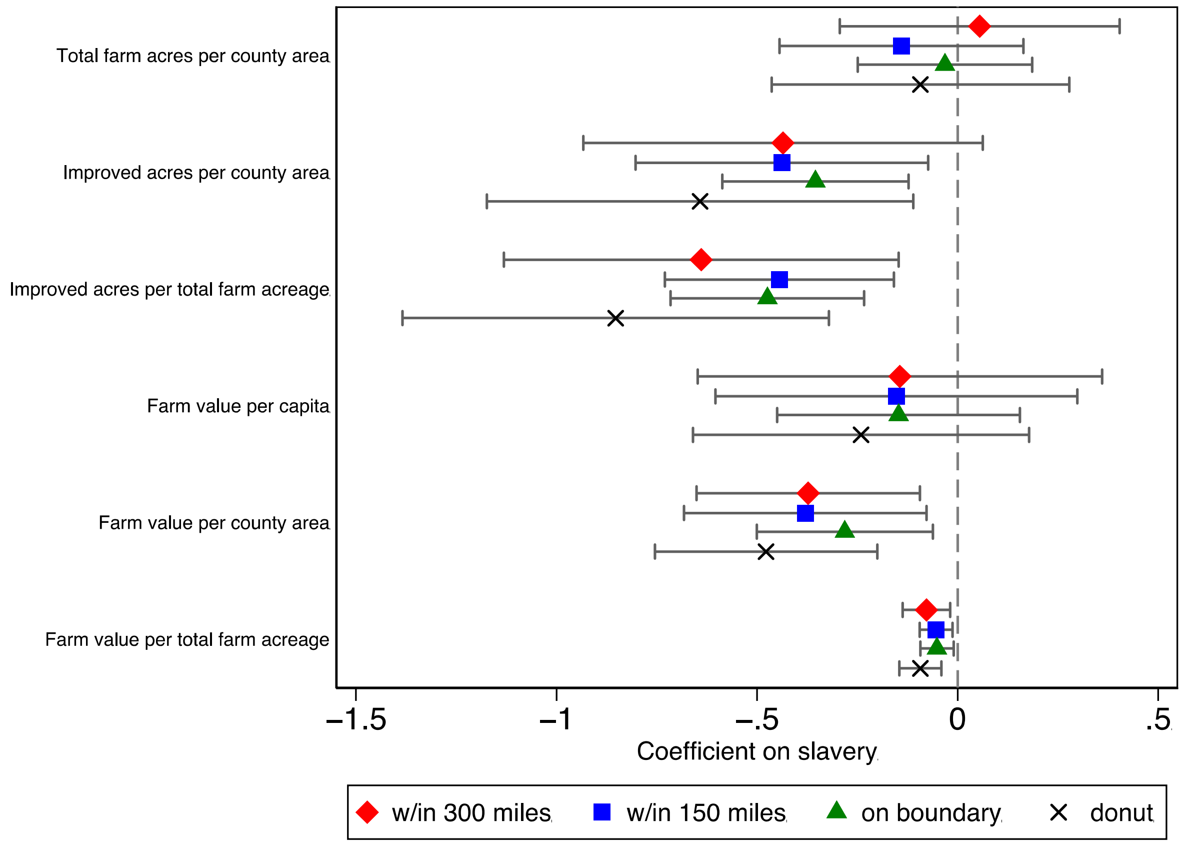
Appendix F: Additional Sets of Results (Sensitivity Analysis for Main Results)

Appendix Figure F-1: Population (z-score)



Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. The outcomes are transformed into z-scores.

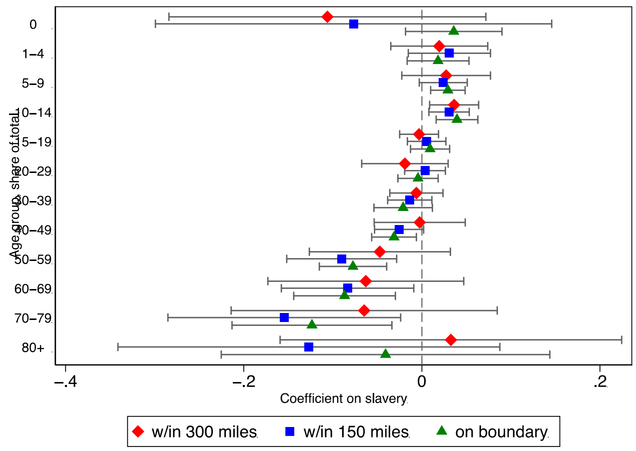
Appendix Figure F-2: Land Use and Land Value (z-score)



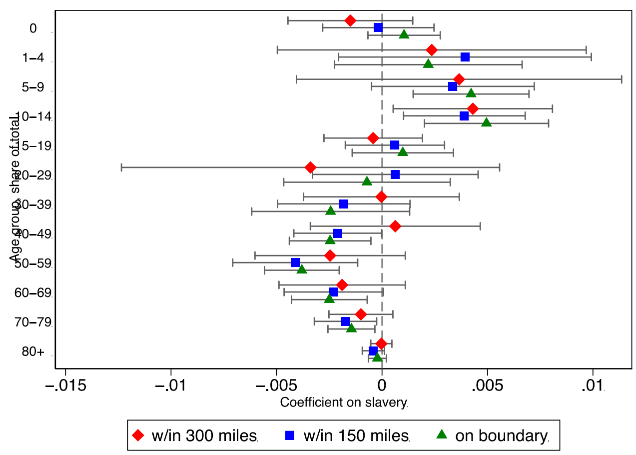
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. The outcomes are transformed into z-scores.

Appendix Figure F-3: Age Composition

Panel A: Logarithm



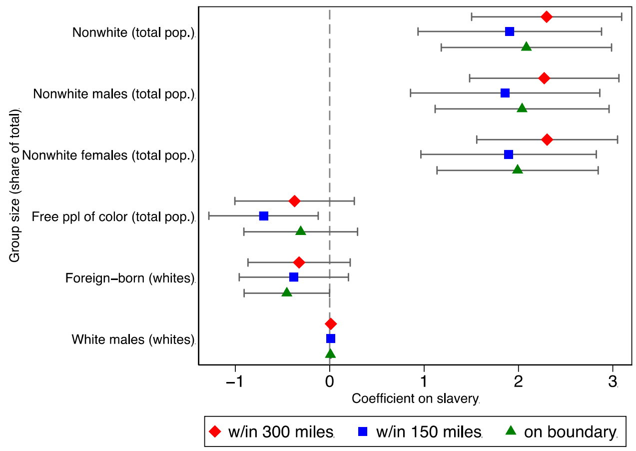
Panel B: Inverse Hyperbolic Sin



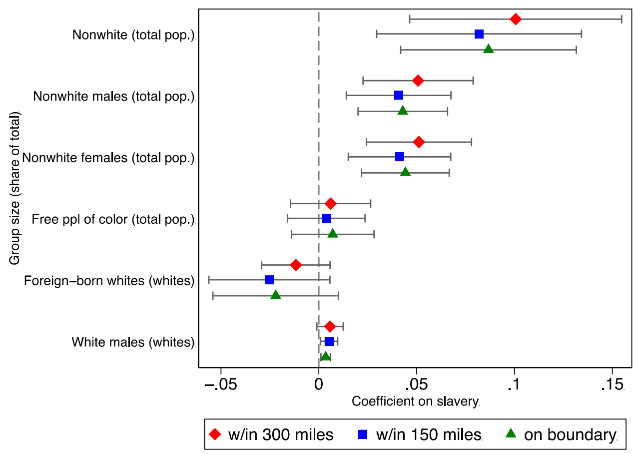
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. For the top panel, the outcomes are transformed into natural logarithms. For the bottom panel, the outcomes are transformed with the inverse hyperbolic sin (asinh).

Appendix Figure F-4: Race and Gender

Panel A: Logarithm

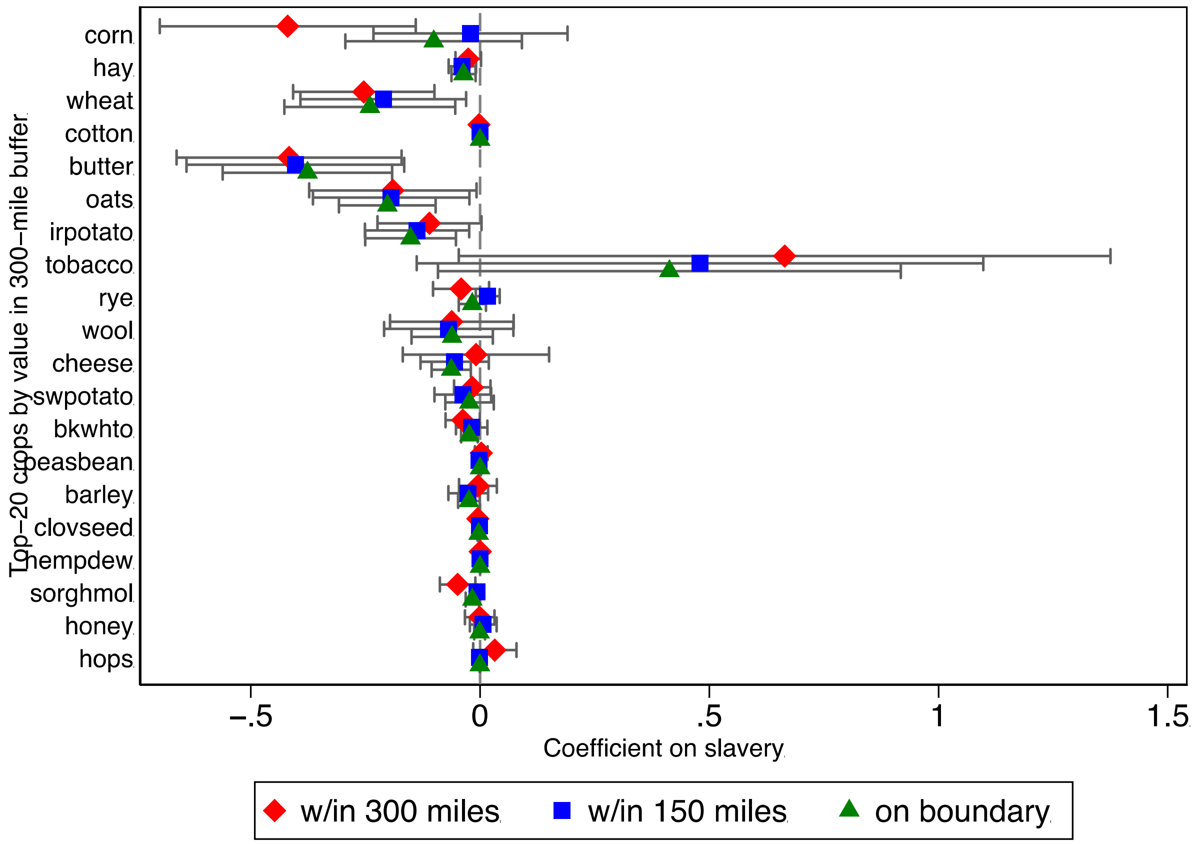


Panel B: Inverse Hyperbolic Sin



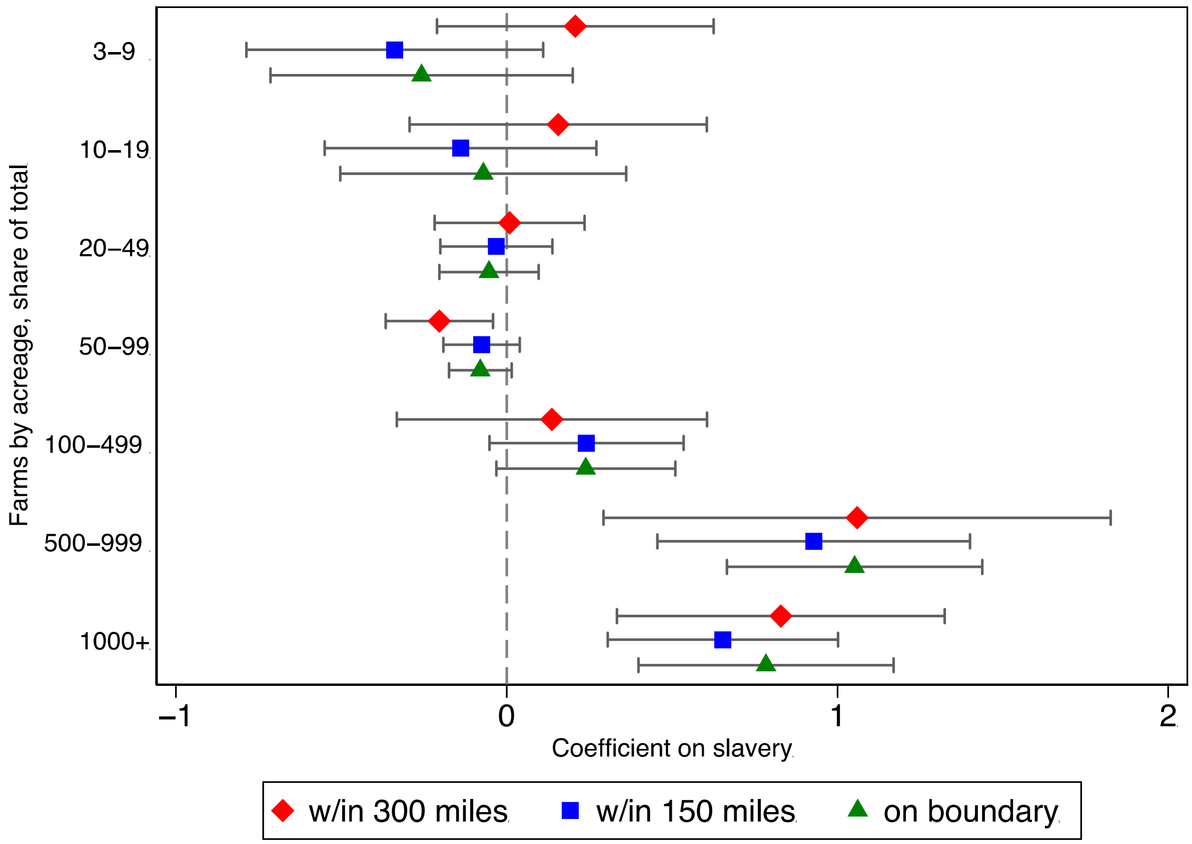
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. For the top panel, the outcomes are transformed into natural logarithms. For the bottom panel, the outcomes are transformed with the inverse hyperbolic sin (asinh).

Appendix Figure F-5: Crops (asinh transform)



Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. The outcomes are transformed with the inverse hyperbolic sin (asinh).

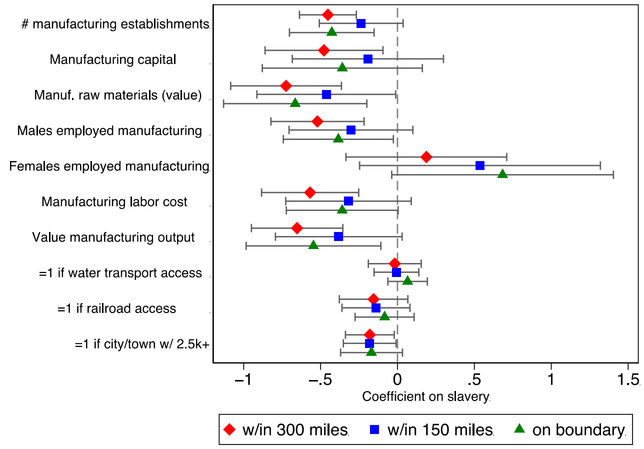
Appendix Figure F-6: Farm sizes (asinh transform)



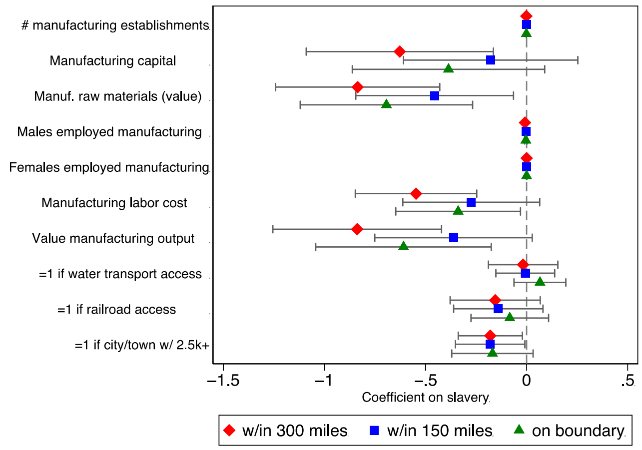
Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. The outcomes are transformed with the inverse hyperbolic sin (asinh).

Appendix Figure F-7: Structural Transformation

Panel A: Logarithm

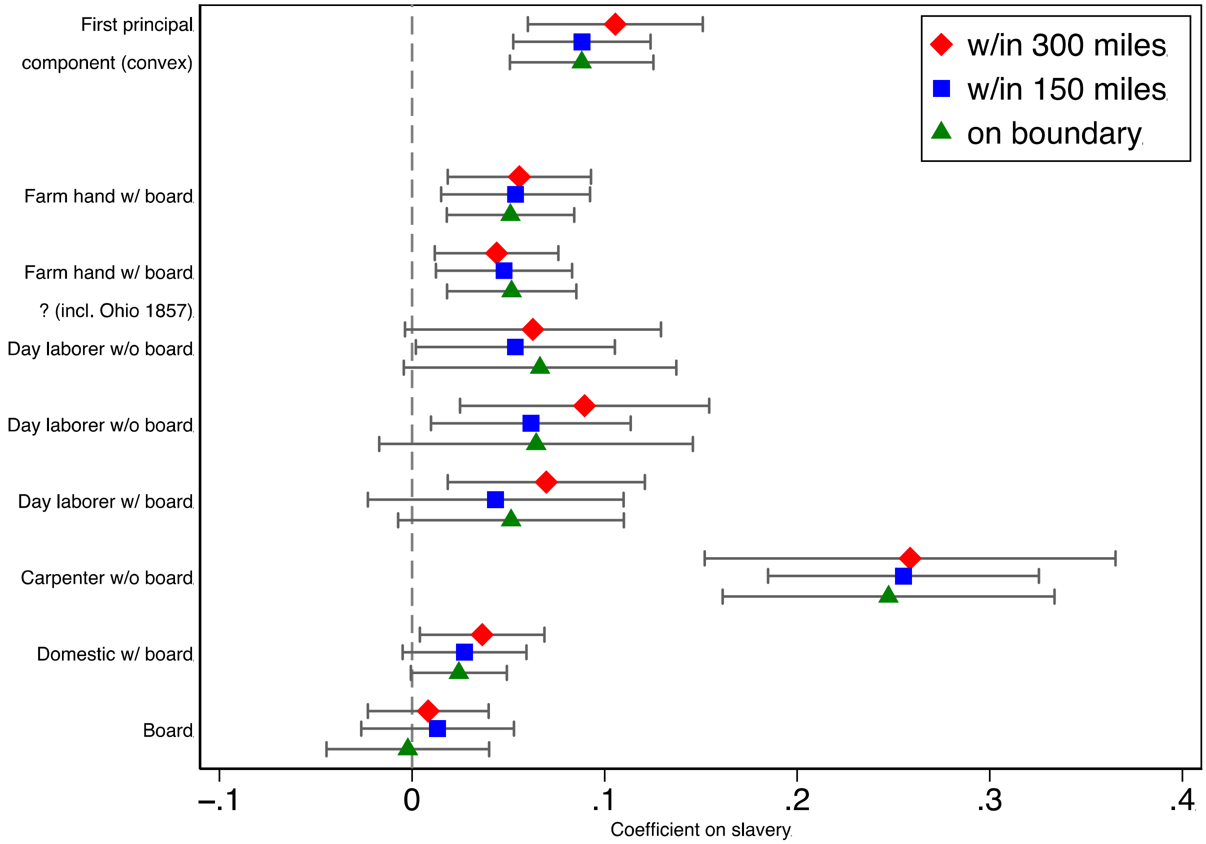


Panel B: Inverse Hyperbolic Sin



Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero. For the top panel, the outcomes are transformed into natural logarithms. For the bottom panel, the outcomes are transformed with the inverse hyperbolic sin (asinh).

Appendix Figure F-8: Wages (levels)



Notes: This figure presents point estimates and confidence intervals for the coefficient on slavery for the outcomes indicated in the row label and for various samples of counties. Point estimates are denoted with symbols within horizontal bands denoting 95-percent-confidence intervals. Standard errors are estimated using 15 quantiles of longitude as clusters. Each symbol type the notes a distinct sample: red diamond for counties within 300 miles of the boundary, blue square for counties within 150 miles of the boundary, and green diamond for counties adjacent to the boundary. The vertical, dashed line denotes a null hypothesis of zero.

Appendix G: Data on Wages

The Census of Social Statistics reported wages. Stanley Lebergott (1964) reported the state-level data. Robert Margo (2000) analyzed a large sample of county-level data that he collected from the surviving manuscript records. The Census Marshalls reported information on the average monthly wages of farmhands (with board), daily wages of day laborers (with and without board), daily wages of carpenters (without board), the weekly wages (with board) of female domestics, and the price of board to laboring men per week. The reports were sometimes separate by township, and we used an unweighted average to construct the county data.

We have sought to use all the data available. We benefited from the data collection efforts of Robert Margo (highest honors), John Clegg, and Vasily Rusanov. We thank these scholars for sharing and making the analysis much easier. We have added data where possible.

Secondary sources for 1860:

- Robert Margo: DC, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Mississippi, Michigan, Nebraska, North Carolina, Pennsylvania, South Carolina, Tennessee, Texas, Virginia.
- John Clegg: Arkansas, Delaware.
- Vasily Rusanov: Minnesota, Wisconsin.
- Bleakley, Rhode: Alabama, Maryland, Maine, Missouri, New York, New Jersey, Ohio (1 county).

Secondary sources for 1850:

- Robert Margo: Arkansas, DC, Florida, Georgia, Indiana, Iowa, Kentucky, Louisiana, Massachusetts, Mississippi, Michigan, New York, North Carolina, Pennsylvania, South Carolina, Tennessee, Texas, Virginia.
- John Clegg: Delaware.
- Vasily Rusanov: Wisconsin.
- Bleakley, Rhode: Alabama, Illinois, Maryland, Maine, Missouri (2 counties), New Jersey, Ohio (1 county).

The Social Statistics schedules for all but one Ohio county (Seneca) are apparently lost. We supplemented US Census Social Statistics with 1857 state data for Ohio for the wages of daily labor and farm hands. These are reported in:

- Ohio Commissioner of Statistics. 1858. Annual Report for 1857. Public Doc. No. 8. Columbus, OH: Richard Bevins, State Printer, pp. 555-65.
- Ohio Board of Agriculture. 1858. *1857* Annual Report. Columbus, OH: Richard Bevins, State Printer, pp. 210-11.

Appendix H: Adaptation of Rosen/Roback Model

The standard Rosen-Roback model has a system of equations involving homogenous firms and households. Both firms and households create the demand for land; firms demand labor and households supply labor. Firms enter until a zero-profit control holds. Households pick the location generating the highest utility.

In the most commonly used variant of the model, land values do not directly enter in the firm's profits, only in the household's utility through a cost-of-housing effect. A higher density of households leads to higher land values. A firm's profits are determined by productivity (positively) and wages (negatively). A household's utility is affected by amenities (positively), wages (positively), and land values (negatively, via housing costs). Prices and quantities adjust to leave firms with zero profit and households with utility equal to their next-best alternative (U^*). The system of equations is:

(1) Profits (Productivity$^+$, Wages$^-$) = 0
(2) Utility (Amentity$^+$, Wages$^+$, Land Values$^-$) = U^*

In spatial equilibrium, the local factor returns are functions of productivity and Amenities. Local land values are higher in places with higher Productivity or higher Amenities. Local wages are higher in places with higher Productivity or lower Amenities (equivalently, higher disamenities).

(3) Land Values (Productivity$^+$, Amentity$^+$)
(4) Wages (Productivity$^+$, Amentity$^-$)

Consider the comparative statics of this model. A combination of higher land value and higher wages is associated with the dominance of higher productivity of local firms. A combination of higher land value and lower wages is associated with the dominance of higher amenity values for households.

A variation more suitable to our case switches the source of the demand for land from households to firms (farms). Farms use land and households choose locations based on amenities (positively), wages (positively). Wages here are a measure of the returns (e.g. marginal product) to labor. Farmland rents will depend on productivity (positivity) and wages (negatively). Rents will determine land values. The equilibrium relationships now are as follows:

(5) Farm Rents (Productivity$^+$, Wages$^-$)
(6) Indirect Utility (Amenity$^+$, Wages$^+$)

This framework leads to the same result as before. A combination of high land value and high wages is still associated with the dominance of higher productivity of local farms. A combination of high land value and low wages is associated with higher amenity values for households. The model's summary interpretation is that the observed combination of lower land prices and higher wages is consistent with a household-side disamenity for free people associated with living and working on the slave side.

We can readily add a second set of households who choose locations based on land values and amenities, instead of wages and amenities. These households may have an autarkic relationship to the labor market, being neither buyers nor sellers of labor. An example would be self-sufficient farm household that depends on its own labor. They do desire cheaper land to increase their holdings.[3]

For these households, locational choice is determined by an alternative utility function without wages.

(7) Alt_Utility (Amentity^{+}, Land Values^{-})

The same equilibrium relations of factor returns remains the same as in (3) and (4). Land values are lower on the slave side. This could arise because of the higher wages for those active in the labor market or because migrants intending to be farmers require a higher land/labor ratio on their farm in order to move there. This is still a sign of household-side disamenities for free people on the slave side.

The following table summarizes the implications of the model:

		Land value of location	
		High	Low
Wages at location	High	productivity is higher (labor demand must have shifted out)	amenity is lower (labor supply must have shifted in)
	Low	amenity is higher (labor supply must have shifted out)	productivity is lower (labor demand must have shifted in)

The results place the slavery counties in the upper right cell: low land value and high wages indicate that labor demand shifted in because of a lower consumption amenity for the mobile workers. Note that this implies nothing about the sign of fundamental productivity differences across the border, other than they are dominated by a lower amenity (or higher disamenity) on the southern side. Migrants demand a higher return to their labor if they are to settle there. This could come as higher wages, as measured, or as cheaper land for a farmer to work.

[3] It is possible that households prefer to locate in areas with low-priced land, for example, to make bequests of farmsteads of a given acreage to their children. See Easterlin (1976) and Schapiro (1982).

Appendix I: Population Movements

The appendix section documents several pertinent patterns related to migration to the border region. Population flows went primarily in an east-to-west direction including significant flows from Virginia and other parts of the Chesapeake into southern Ohio, Indiana, and Illinois. The panels of Figure I-1 map the shares of eastern-born household heads, age 45 to 64, in the 1850 census coming from 6 major regions (New England, New York, Pennsylvania-New Jersey, Maryland-DC-Delaware, Virginia, and North Carolina-South Carolina-Georgia-Florida). Among the eastern born, the Virginians are very common in Kentucky and Missouri, other states of the Border South. But what is notable is their prevalence in Ohio, Indiana, and Illinois, the Border North. The shares in these Free states are higher than the Virginians' share in the Deep South. And in the Midwest, New Yorkers and New Englanders appear to dominate only in the areas near the Great Lakes.

The flows from Virginia to the Free States was substantial. In 1850, among heads-of-households born in Virginia, age 34 years and over, 27.9 percent resided in the Free States. In the 1860, the fraction was 25.4 percent. This population may not have been philosophically against slavery, but they did vote with their feet not to live in the region where slavery was legal.

The extent of south-north migration appears larger than commonly thought. The share of heads-of-household moving was much higher than the more conventionally-measured share of total free population moving. Children were much more likely to be recorded residing in their state of birth than were adults. Adults were making the location decisions and are the more relevant reference group.

Table I-1 compares the retention rates of heads-of-household and total free population between the free and slave states. The retention rate is the percent remaining in the region of birth; those not retained obviously shifted between regions. The measured shifts are much higher for heads-of-households (about 1 in 8) than for the total free population (1 in 20). The fraction of household heads born in a slave state who moved to reside in a free state – coming close to 1 in 4 – is especially notable. The fraction is substantially higher than that for moves in the opposite direction, born in a free state and residing in a slave state. The difference in retention rates is sufficiently large to create a net movement of household heads from slave states to free states despite the larger fraction of household heads born in free states.

The preference of movers for the Free states is evident if one examines longer distance moves, from non-border states and foreign counties to the border counties. The destination choices for such moves were not constrained from the desire to move along given latitude. Tables J-2 and J-3 present data of the free-side/slave-side choices for male heads of households, ages 25 years or more, residing in the border counties in 1860. The border states are indicated in italics and the slave states are indicated in bold type. The second panel in Table J-2 reports results separately for free persons of color.

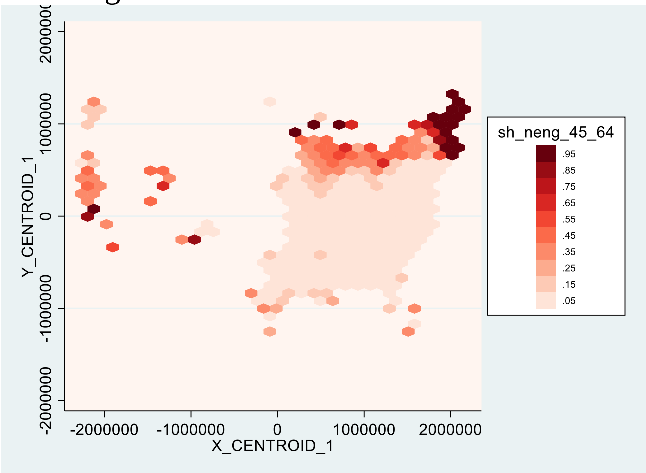
The ratios report the prevalence of residence on the free side relative to the slave side. Four results stand out. (i) it is uncommon for persons born in free states to reside to reside on the slave side. Those born in free states tended to live on the free side; the ratio of own to other was 6 to

1. Those born in slave states tended to live on the slave side, the ratio of own to other was 2 to 1. Thus, switching was more common for those born on the slave side than those born on the free side. (2) for longer distance moves (from states not on the border), both southerners and northerners tended to live the free side; (3) it is very uncommon for free persons on color from non-border states to reside on the slave-side; (4) the foreign-born also tended to the free side, but the ratios actually closer to parity than for US born male HHs from the non-border region. These patterns were not new to 1860, and indeed predate the sharp regional conflicts of the 1850s. Table 3 present data of the free-side/slave-side choices for US born male heads of households, ages 25 years or more, residing in the border counties in 1850. (The Census of 1850 is the first to include information on state of birth. At this date, it is already uncommon for those born in free states to reside on the border counties on the slave side.

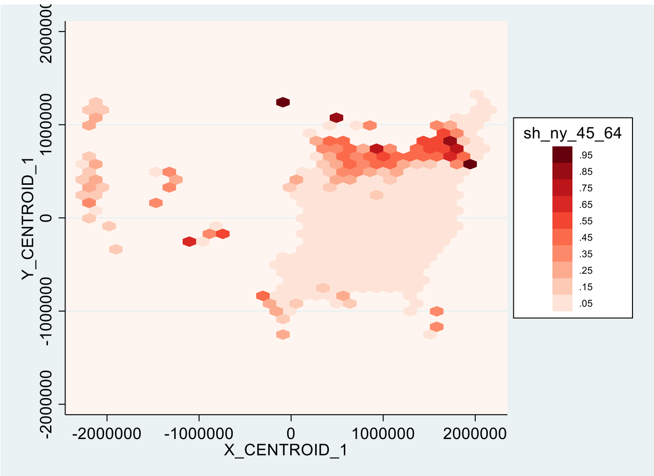
The source for the 1850 and 1860 Full Count Census data used in Figure 1 and Tables 1-3 is Steven Ruggles, Sarah Flood, Sophia Foster, Ronald Goeken, Jose Pacas, Megan Schouweiler and Matthew Sobek. IPUMS USA: Version 11.0 [dataset]. Minneapolis, MN: IPUMS, 2021. https://doi.org/10.18128/D010.V11.0

Figure I-1: Share of 6 regions in 1850 Heads of Household, aged 45-64 year, Born on East Coast

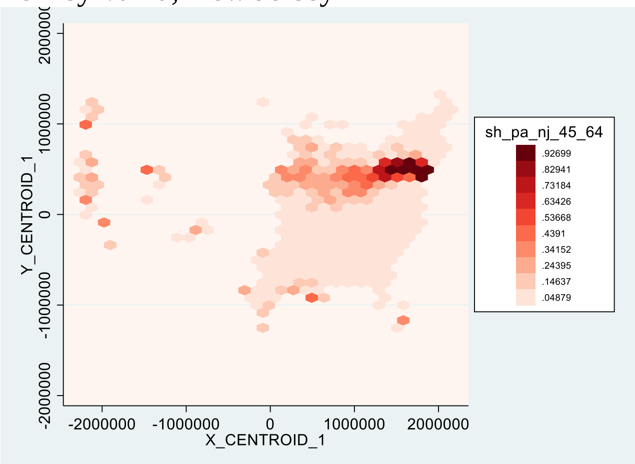
New England



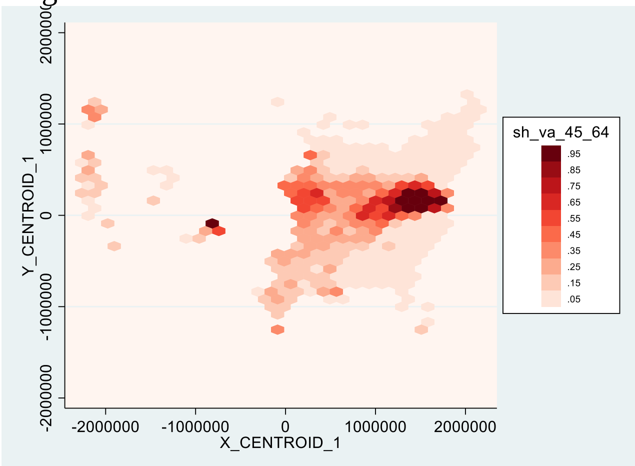
New York



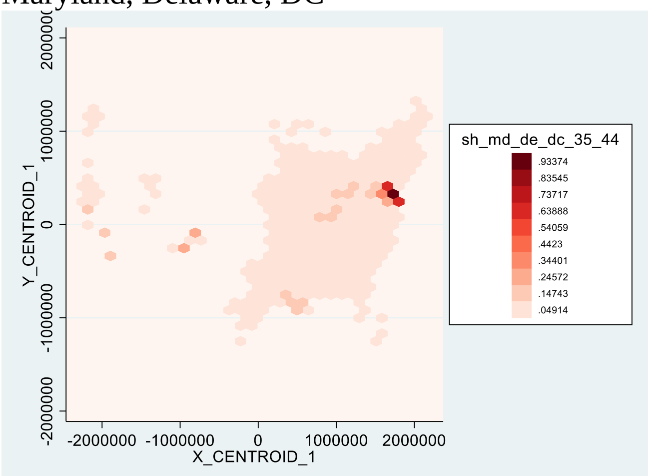
Pennsylvania, New Jersey



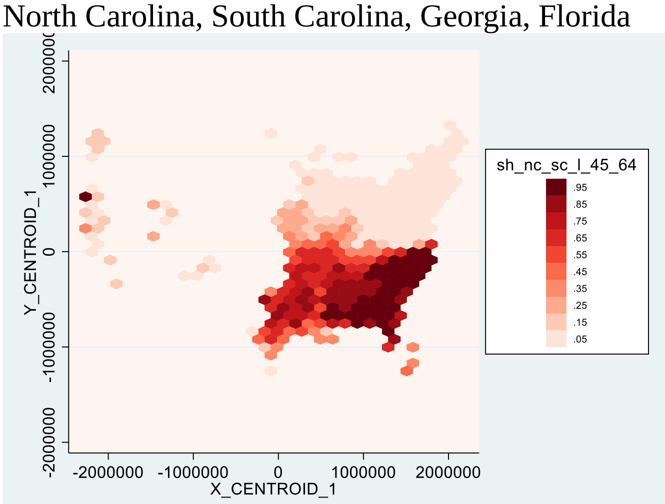
Virginia



Maryland, Delaware, DC



North Carolina, South Carolina, Georgia, Florida



Source: Compiled from 1850 IPUMS Full Count Census

Appendix Table I-1: Comparison of Retention Rates for Heads of Households and Free Population

Birth\Resident	Slave State	Free State	Total	% Retained
Heads of Household				
1850				
Slave State	896,944	264,469	1,161,413	77.2
Free State	85,638	1,849,185	1,934,823	95.6
Total	982,582	2,113,654	3,096,236	88.7
1860				
Slave State	1,114,557	304,173	1,418,730	78.6
Free State	143,615	2,428,648	2,572,263	94.4
Total	1,258,172	2,732,821	3,990,993	88.8
Free Population				
1850				
Slave State	5,966,230	648,168	6,614,398	90.2
Free State	227,239	10,505,338	10,732,577	97.9
Total	6,193,469	11,153,506	17,346,975	95.0
1860				
Slave State	7,481,837	760,965	8,242,802	90.8
Free State	390,151	14,703,287	15,093,438	97.4
Total	7,871,988	15,464,252	23,336,240	95.1

Compiled from Census Full Count for 1850 and 1860.

Appendix Table I-2: 1860 Residents in Border Countries by State of Birth

Male HH Age 25 and over				Free People of Color		
Birth\Reside	Free	Slave	Ratio	Free	Slave	Ratio
Total	204,066	111,541	1.83	6,127	5,831	1.05
Birth-State Slave	41,237	84,622	0.49	3,371	5,682	0.59
Birth-State Free	162,829	26,919	6.05	2,756	149	18.50
Not-Border	21,317	11,891	1.79	501	88	5.69
Birth-State Slave	8,152	6,334	1.29	462	59	7.83
Birth-State Free	13,165	5,557	2.37	39	29	1.34
Individual States						
Delaware	1,616	11,393	0.14	324	2278	0.14
Kentucky	10,968	27,201	0.40	427	384	1.11
Maryland	6,545	26,257	0.25	709	2,692	0.26
Missouri	823	3755	0.22	33	53	0.62
Virginia	12,991	9,531	1.36	1,391	211	6.59
DC	142	151	0.94	25	5	5.00
Illinois	5194	809	6.42	102	8	12.75
Indiana	10,911	2088	5.23	67	4	16.75
Iowa	445	261	1.70	1	1	1.00
New Jersey	12,371	1,211	10.22	522	12	43.50
Ohio	36,065	5,404	6.67	285	15	19.00
Pennsylvania	84,678	11,589	7.31	1,740	80	21.75
Alabama	198	135	1.47	20	1	20.00
Arkansas	37	36	1.03	3	0	
Florida	5	10	0.50	0	0	
Georgia	238	175	1.36	35	6	5.83
Louisiana	116	132	0.88	24	12	2.00
Mississippi	102	72	1.42	36	4	9.00
North Carolina	2,792	2,014	1.39	140	17	8.24
South Carolina	697	442	1.58	42	6	7.00
Tennessee	3,955	3,310	1.19	159	13	12.23
Texas	12	8	1.50	3	0	
Connecticut	1,214	477	2.55	1	1	1.00
Maine	762	333	2.29	0	0	
Massachusetts	1,948	989	1.97	5	24	0.21
Michigan	66	49	1.35	1	0	
Minnesota	2	4	0.50	0	0	
Nebraska	2	0		0	0	
New Hampshire	737	241	3.06	0	0	
New York	6,169	2,958	2.09	29	4	7.25
Rhode Island	265	99	2.68	2	0	
Vermont	1962	400	4.91	0	0	
Wisconsin	38	7	5.43	1	0	

Appendix Table I-3: 1860 Foreign-Born Residents in Border Counties by Country of Birth

Male HH Age 25 and over

Birth\Reside	Free	Slave	Ratio
Total	79,745	57,666	1.38
Britain (incl. Ireland)	28,193	24,233	1.16
German-Austrian-Swiss	45,473	28,832	1.58
Other	6,079	4,601	1.32
Canada	636	508	1.25
West Indies	641	411	1.56
Denmark	84	102	0.82
Norway	33	12	2.75
Sweden	94	71	1.32
England	7,197	4,740	1.52
Scotland	1,812	1,101	1.65
Wales	1,088	473	2.30
Ireland	18,096	17,919	1.01
Belgium	135	88	1.53
France	3,452	2,137	1.62
Netherlands	500	255	1.96
Switzerland	2,029	1,104	1.84
Italy	183	221	0.83
Austria	263	232	1.13
Czechoslovakia	126	625	0.20
Germany	43,181	27,496	1.57
Hungary	46	35	1.31
Poland	149	136	1.10

Source for Tables J-1 and J-2: Compiled from IPUMS 1860 Full Count Census

Appendix Table I3: 1850 Residents in Border Countries by State of Birth

Male HH Age 25 and over	Free	Slave	Ratio
Total	169,737	97,130	1.75
Birth-State Slave	40,142	80,766	0.50
Birth-State Free	129,595	16,364	7.92
Not-Border	19,187	10,486	1.83
Birth-State Slave	7,735	5,421	1.43
Birth-State Free	11,452	5,065	2.26
Individual States			
Delaware	1,659	10,176	0.16
Kentucky	9,768	18,847	0.52
Maryland	7,204	33,350	0.22
Missouri	479	2,576	0.19
Virginia	13,181	10,039	1.31
DC	116	357	0.32
Illinois	2,297	273	8.41
Indiana	4,846	549	8.83
Iowa	491	136	3.61
New Jersey	11,895	1,188	10.01
Ohio	22,685	1,794	12.64
Pennsylvania	75,929	7,359	10.32
Alabama	135	79	1.71
Arkansas	15	12	1.25
Florida	4	12	0.33
Georgia	312	238	1.31
Louisiana	100	163	0.61
Mississippi	76	81	0.94
North Carolina	2,864	2,242	1.28
South Carolina	1,120	576	1.94
Tennessee	3,105	2,010	1.54
Texas	4	8	0.50
Connecticut	1,339	423	3.17
Maine	722	334	2.16
Massachusetts	1,940	1,076	1.80
Michigan	27	24	1.13
Minnesota	-	8	0.00
Nebraska	2	1	2.00
New Hampshire	709	264	2.69
New York	5,412	2,448	2.21
Rhode Island	259	155	1.67
Vermont	1,039	327	3.18
Wisconsin	3	5	0.60

Source: Compiled from IPUMS 1850 Full Count Census

Appendix J: Adjusting for Buildings and Improvement and Calculating Total Factor Productivity in Agriculture

Building Values and Clearing

To adjust farm values for differences in the value of buildings and improvements, we follow the practices laid out by Tostlebee (1957), Primack (1975), Lindert (1989a, 1989b) and Gallman (1972).

Building Values

These authorities report structures as being almost one-fifth of farm value. Subtracting the estimated value of buildings from the farm values yields an estimate of the value of "land alone" (see Primack 1975; Lindert 1989a, 1989b). For 1860, Gallman (1975) reports a national structure share of 0.23 whereas Gallman and Rhode (2019, pp. 19, 29) have this proportion at 0.19. Primack (1965, Table 1) reports the structure share in farm value is 0.18 in 1860, with the ratio varying by state. use the Primack's building-farm value ratios reported at the state level. (County-level data are available in the Census in 1900, but these appear less relevant to conditions in the antebellum period than the estimates Primack provides.) Using the state-level parameters makes comparisons in the border sample somewhat problematic. The changes may be artificially sharp at the points where the parameters shift as in the border counties. Comparisons in the 150-mile sample and 300-sample are not so greatly affected.

Land Clearing

The literature offers various ways to adjust for differences in land clearing. Removing the estimated value of land improvements from that of "land alone" yields an estimate of the site value of "raw" land. to create a value for "raw" land.[4] One approach to model the ratio of the value of improved to unimproved land. Gallman (1972) puts the 1860 national ratio at 2, which would imply that the per acre value of unimproved land is (1/(1+fraction improved)) times the per acre value of "land alone."

A second approach is to estimate the value of labor applied to land clearing (see Primack 1975; Gallman and Rhode 2019). The subtraction method produces a rather noisy measure. In some counties, the estimated cost of clearing an acre (required labor times daily wage) exceeds the value of "land alone"; the estimated value of "raw" land there was negative. Based on the subtraction approach, Gallman estimated the national ratio of improved-to-unimproved land in 1860 was around 2.5 (=12.50/5.01). See Table 7.12 in Gallman and Rhode 2019, p. 198. Gallman considered this ratio to be upward biased because off-peak family labor was deployed and may have lower value than the farm wage used in the calculation and the actual clearing was likely less thorough and requires less land than what was assumed.

Tostlebe (1957, p. 179) put the improved-to-unimproved ratio at 3 in the humid east and 1.5 in Illinois, Iowa, and the Great Plains. His assumptions were based on the lower cost of land clearing in prairie land than in woodland. Lindert (1989a, 1989b) adopts Tostlebe's approach. This approach does allow for environmental variability.

[4] An alternative, older approach was to regress farm values on the share of land improved. This analysis suffers, in obvious ways, from potential omitted variable biases.

Total Factor Productivity

To calculate TFP in agriculture, we follow the approach of Fogel and Engerman (1971, 1974). The main differences are two-fold. We conduct the estimation at the county level as opposed to the regional level (North versus South). And as a result of our more local focus, we use Thomas Weiss's county-level estimates of the agricultural labor force, as discussed below.

<u>Output</u>

The approach starts with the allocation to national agricultural output from Towne and Rasmussen (1960) across the subunits. This exercise assumes uniform national prices and well as seeding and feeding rates (to generate net outputs). We use gross farm output (from Table 1, p. 265), livestock outputs (Table 5, p. 282), crop outputs (Table 6, p. 291) and add the value of home manufactures and of improvements to land.

For most of the commodities, we can allocate the Towne and Rasmussen output values in straightforward ways, based on the county-level shares of national production from the US Census. (See ICPRS Study No 35206). The procedure is applied for Sheep and lambs, Hogs, Wheat, Rye, Corn, Oats, Rice, Tobacco, Cotton Lint, Wool, Peas and Beans, Irish Potatoes, Sweet Potatoes, Barley, Buckwheat, Fruits, Truck Crops, Hay, Hops, Hemp, Flax, Flaxseed, Maple, Sugar Cane, Maple Molasses, Cane Molasses, Sorgo, and Home Manufactures. For Miscellaneous Animal Products, the production of Honey is used to allocate the total. For Dairy Products, the distribution of milk cows was used. For Cattle and related produces, the distribution of other cattle and oxen was used. For Horse Production, the distribution of horses and mules was used. The Census data provided no straight-forward way to allocate the production of Chickens, Eggs, and Other Poultry, Forest Products, Nursery Production, and therefore these products were ignored.

As noted by Engerman (1972), allocating the Towne and Rasmussen output yields output estimates using uniform national prices. (This contrasts with the income originating approach using state level prices.)

The value of farm improvement was allocated on the basis of estimated land clearing, construction, and fencing. As with Fogel and Engerman (1971), the approach was inspired by the work of Martin Primack (1977). Gallman's work on Agricultural Capital as represented in Gallman and Rhode (2019) was also informative. The county level sums were generated from three estimates:

(1) Land clearing: value estimated as the positive change in improved acreage by county between the 1850 and 1860 censuses times the Primack's labor requirement per acre (which depended on whether forest or prairie) times the state-level daily farm wage.
(2) Farm construction: value estimates as the positive change in number of farms reported by county in the 1850 and 1860 census times the building-to-total-value ratio times 1860 farm values divided by 1860 number of farms. The building-to-total-value ratio is based on Primack's state-level building-to-land estimates as reported on pp. 164-65, 174-76 of his dissertations
(3) Fencing: value estimated as the positive change in total acres reported by county in the 1850 and 1860 census times Primack's labor requirements per newly fenced acres times the state-level daily farm wage.

These three values were summed for each county, and the county's share of the total was used to allocate the national figure for improvements to farms reported in Towne and Rasmussen. The daily farm wage was estimated as the monthly wage divided by 26.

Capital

The stock was the sum of equipment value, livestock values, and building values. The first two were taken directly from the US Census (1864). Following Fogel and Engerman (1971), building values were estimated based on 1860 Farm Values (from the Census) and Primack's State-Level Building-to-Land Ratio, introduced above. Following Fogel and Engerman (1971), the capital stocks were converted to flows assuming ratio of 0.2 for equipment, 0.1 for livestock, and 0.12 for buildings.

Land

Following Fogel and Engerman (1971), the stock of land was the sum of improved and unimproved acreage was reported in the US Census (1864) and ICSPR No. 32206. We also create an alternative index for land upweighting the contribution of improved land. Following Gallman (1972), we treat improved land as twice (2 times) as valuable as unimproved land.

Labor

The county-level labor stock was the sum of four components from the work of Thomas Weiss: Rural Agricultural Free Males, under 15; Rural Agricultural Free Males, 16 years and older; Rural Agricultural Slave Males, 10 years and over; and Rural Agricultural Slave Females, 10 years and over. (See Craig and Weiss.) These series were created after Fogel and Engerman (1971, 1974) and differ somewhat from the estimates based on Lebergott (1966) used therein. Weiss assumed a lower fraction (0.74) of enslaved workers in rural areas worked in agriculture than Lebergott did (0.90); Weiss took the share devoted to domestic service to be higher. Weiss does employ certain state-level parameters, which may affect the sharpness of changes at the border. We create two estimates of the county-level agricultural labor forces, the first using Weiss's numbers reflecting his preferred labor force participation rates and the second adjusting the slave labor force upward to reflect Lebergott's higher estimate (that is, Weiss's slave labor force in agriculture is boosted by 1.216216=0.90/0.74, everywhere). The two alternatives yield different estimates of the input bundles and of productivity.

Inputs and TFP

Following Fogel and Engerman (1971), capital (K), land (T), and labor (L) was combined in a Cobb-Douglas function with weights of 0.2, 0.2, and 0.6. That is, input bundle=$K^{0.2}T^{0.2} L^{0.6}$. Fogel and Engerman (1974) use slightly different weights. Total Factor Productivity is measured as output divided by the input bundle, or TFP=$Q/(K^{0.2}T^{0.2} L^{0.6})$. There are two estimates, the first reflecting Weiss's approach and the second, Lebergott's. In each case, Q, K, T, and L are normed to the national total, and thus are shares of the national aggregates. The county-level TFP estimates are relative to the national mean of 1, that is unity.

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