Was Free Soil Magic Dirt?

Endowments versus Institutions in the Antebellum United States

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Abstract: In the Antebellum United States, "free soil" areas had greater economic development than the areas where slavery was legal, yet free farming did not displace slave-based agriculture in the slave states. Was free soil a "magic dirt," or could free farms compete in the slavery-legal region? We consider three classes of tests. First, we construct, separately for the two regions, suitability indices using soil and climate endowments. The indices suggest free-soil techniques could have prospered in the Upper South. Second, we show that endowments earning a high (hedonic) return on free soil received little return where slavery was legal. Third, we randomly sample farmers from the 1860 agricultural census in Kentucky and compare them to free farmers in states across the Ohio River. Kentucky farmers without slaves had farms of lower value per acre but produced more output per farm value than either their slave-owning neighbors or farmers in the neighboring free states. Together, this evidence indicates that a free-soil society could have thrived in the border South but prevailing institutions held back free farms.

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Over a very long time, a heterogeneous set of commentators have touted the economic prowess of the slave system. But the reality is that, in the United States, the slave states were falling behind the free states on many key metrics. Per square mile, the Southern states in 1860 had less than half the population and output of the North. Along the border between free and slave states, there was a 50 percent higher rural population density on Free Soil (Bleakley and Rhode 2022).[1] Migration (including from Southern states) drove faster population growth where slavery was prohibited (Bleakley and Rhode 2023). Yeoman farmers followed Horace Greeley's command to "Go West, Young Man," in pursuit of cheaper and emptier land. But the movement west showed a northern bias, even though land was pricier and wages lower on Free Soil. There was also more innovation and urbanization in the North. The region with free farming was ascendant.[2]

With this proof of concept for free labor, why did yeoman farming not displace slave-based agriculture immediately to the south? How did the slave system compete if free farmers had higher demand for land? Or was Free Soil Magic Dirt? "Free Soil" refers to an ideology and a bundle of institutions in the states where slavery had been prohibited, e.g. in the Old Northwest. It rejected labor coercion and endorsed the use of public land for settlement by small holders. It followed from the Jeffersonian dream of yeomen farmers with economic agency, which in turn readied them for political agency. The phrase "Magic Dirt" is itself something of a parody of geographic and ecological determinism.[3] Ecology matters, of course, but sometimes development differences clearly derive from the organization of society instead, as seen on either side of

[1] Specifically, in Bleakley and Rhode (2022), we compare neighboring places with similar environments rather than distant, different places—the Deep South and the North—as the previous literature had done. We also sought to distinguish between the effects on mobile and immobile factors. We found that land on slavery-legal side was underused (lower population density and farm value). In summary, in the borderlands, half of the land was half underutilized on the slavery-legal side. Additionally, we showed that wages were higher there. Combined, these results demonstrate a dis-amenity: free labor did not want to work alongside slavery. Wright (2006) has observed that the southern states were doing well by the slave system's own metrics, generating high wealth per slave holder.

[2] An earlier literature suggested slavery thrived in more productive environments. Bushman (2018) cites climatic conditions, specifically the length of the growing season, as defining the border where slave labor prevailed. The prior literature (see Wright 2006 and Majewski 2016) also focused on conditions within the slavery-legal region and found positive relationships between measures of performance (population density and farm values per farm acre) and the prevalence of slavery (slave density and percent enslaved). This "within regime" finding directed attention away from the "between regime" result that the legality of slavery was associated with lower performance. Gavin Wright (2006) noted that the free soil and slavery-legal regimes were developing differently. Each was, in some sense, a success by its own metrics and a failure by the other's. But the conditions in the slavery-legal regime in the late antebellum period did not lay the foundations for long-run economic growth.

[3] We thank Gary Libecap for discussions leading us to think harder about the sub-regional variations in the environment affected social forms and economic outcomes.

the border of the two Koreas, or of the (then) two Germanys. There, differences in development come from differences in institutions, not in the ecology or in the people.

We use a rich set of geographic variables to gauge what package of endowments made for a successful location under different institutions, specifically under Free-Soil and slavery-legal regimes. Consider the following schema:

natural endowments	→	technology & institutions	→	Outcomes (e.g. land demand)

In words, the mapping from endowments to outcomes is determined by a combination of technology and institutions. To measure endowments, we collect county-level data on topography, soil, and climate, inter alia. We use them to predict 1860 rural-population density. To deal with overfitting, we use a ridge regression (ℓ_2 penalty on coefficients) for each region. Effectively, we estimate an institution-specific index of suitability for settlement by an agricultural population. With these indices, we ask if regional differences arose because of different endowments or differences in how each institution valued those endowments.

In the slave states, there was an ample supply of endowments conducive to Free-Soil agriculture, as we show in Section III. The index calibrated on Free Soil has high values for much of South, usually higher than the index calibrated where slavery was legal. (The Free-Soil index does not give disproportionate weight to the platted and glacier-till areas of the Old Northwest.) If we consider the average index by distance to the free-slave border, Free-Soil suitability is actually rising as we leave Free Soil and head south (Figure 6). The average peaks around 250 miles into the slave states, and returns to its value at the border after 500 miles. (For reference, Atlanta is about 275 miles and the median white Southerner was less than 150 miles from this border.) This range covers all of the Upper South, in fact quite a bit of the Deep South. So, from an environmental perspective, Free Soil could have succeeded far into the region where slavery was legal. We obtain this result even for Southern counties with variables strictly within the support of all of the endowment variables, although there are few such counties past 200 miles from the border. Conversely, the index calibrated where slavery was legal has some high values in Iowa, Illinois, Wisconsin, and Ohio as well, which suggests that the legal constraint on slavery north of the border had an effect.

Nevertheless, the indices calibrated in one region have, for various outcomes, minimal predictive power in the other region, as shown in Section IV. This result holds even in parts of the slavery-legal region where slavery was uncommon. We show this for a variety of specifications and samples, both for calibration and estimation. When farm value per county acre is the dependent variable, this is a hedonic regression. When the slave-population fraction is the dependent variable, this is a selection equation, as in the Roy model. The slavery-legal index predicts more slave labor, as expected. The free-soil index should have the equal but opposite sign in this regression, but instead is essentially zero. The usual logic of comparative advantage embedded in the Roy model is broken here; something prevents free-soil technologies from succeeding where slavery is legal. This calls to mind Hinton Helper's comment that the planters take all the good land and yeomen get whatever is left.

So, in one region, they do not take up the opportunity provided by the package of endowments valued in the other region. On Free Soil, it is clear why: slavery was prohibited. Where slavery was legal, however, farms with only free labor were not prohibited. Indeed, they were the vast majority of farm units in the Upper South. In Section V, we ask: how did farms using only free labor fare in either system?

To measure farm performance by region and labor type, we collect a new sample of farms in Kentucky from the 1860 Census of Agriculture. This fills in a gap between earlier publicly available datasets: Bateman and Foust (1976) covered northern farms and Parker and Gallman (1991) covered the cotton South. We transcribe the farm data from 30 randomly selected pairs of pages, for up to 80 farms per draw. We hand link 98 percent of operators to the 1860 population schedule to obtain household demographics, including family labor. We then search for each operator in the 1860 slave schedule to measure whether and how much slave labor was present on the farm. Our analysis compares "free" and "slave" farms in Kentucky. We add free farms in Illinois, Indiana, and Ohio, states on Kentucky's northern border.

Farmers using only free labor in Kentucky were paid a premium, which we interpret as compensating for free labor's aversion to being where slavery was legal. Free farmers in Kentucky were on worse land but received higher gross land return, effectively increasing their proprietor's income by 8 percent. This is comparable to earlier estimates of a 9 percent wage premium for residing in the region with slavery (Bleakley and Rhode, 2022) and consistent with contemporary writing indicating a preference by free labor to live on Free Soil (Bleakley and

Rhode, 2023). The premium is robust to controlling for local circumstances, all the way to comparing adjacent farms on the same page. This is inconsistent with Alexis De Tocqueville's claim that Kentucky farmers were indolent, but is consistent with Hinton Helper's claim that the slaveholders took the better land. Consider some land that is equally productive under either mode of production. Planters (by definition slaveowners) would have a higher willingness to pay than yeomen farmers, because the latter had an alternative on Free Soil, without the disamenity. In equilibrium, the free farmers would be found where land values are low.

So, was Free Soil Magic Dirt? No, or at least it was not an intrinsic feature of the location. Instead, its success was a product of human creation. The successful economic development of Free Soil should have been possible further south, but it was suppressed by the institution of slavery.

I. Half Free, Half Slave?

The phrase, "Half Free, Half Slave," is often applied to the antebellum United States (Levine 1992). But it belies an important fact: growth in the North was leaving the South behind. Apologists for the economic system of the slave states observed regional incomes were similar on a per-capita basis. But the success of a frontier society – with land abundant relative to the Old World – lay in using land more intensively.[4]

The fifty-fifty split had been approximately correct at the nation's founding. But, as Figure 1 displays, the division had dramatically changed by the 1850s. Population growth was much more rapid in the free states, even before the advent of mass migration from Europe in the late 1840s.[5] The share of the slave South in total US population fell below 45 percent by 1840 and its share of the free population fell to about one-third at this time. Mass migration only intensified the sectional imbalance. By 1860, the slave South's share of the total population was below four-tenths and its share of the free population was near three-tenths.

[4] Hinton Helper (1857) observed that southern economic performance was unimpressive when judged on basis of the extent of economic activity per land area whereas Beebe (1860) asserted the region was doing well when economic performance was measured on a per capita basis. As financial capital and free labor could move to obtain their best returns, we would expect per capita income to be similar across areas within a country. This undermines the useful of per capita income as a metric for comparing performance. In contrast, the existence of otherwise comparable land with different output (per unit areas) represents a productive inefficiency (a failure to arbitrage). This, standard economic reasoning favors Helper's metric: output per area. In general, analysis of the effects of a local or regional policy should consider the price of immobile factors and the quantity of mobile factors.

[5] We are defining the free-slave regions by their division post-1820, after the Missouri Compromise.

Measures of economic activity mirror these patterns. Evidence from Lindert and Williamson (2016) indicate that the "colonies" and "states" below what-became-the-Mason-Dixon line generated about 56 percent of income in 1774 and 45 percent in 1800. By 1860, their implied fraction was less than one-third. The numbers of Easterlin (1960, 1961) and Fogel and Engerman (1974, p. 264) paint a similar picture for the late antebellum period.[6]

The relative growth rates of economic activity and population had important consequences for political balance. The slave South's share of membership in the US House of Representatives was always less than one-half, lying between its share in the total population and that of the free population (due to the three-fifths compromise). In absolute numbers, the South's count of representatives peaked at 100 members in 1830. By 1860, the count was down to 85. The South's share of the Senate fell below 50 percent with the admission of California as a free state in 1850. (No Slave state had been added after the annexation of Texas in late 1845.) The South had long held more territory than the North, but with the conquests from Mexico even this balance shifted after the late 1840s.

Our previous work (Bleakley and Rhode 2022) showed the competitive advantages of the free-soil regimes were apparent locally, in the border region. Population density and real estate values per acre were higher in the free-soil side than in the slavery-legal side. Yet the free-soil regime was not pushing slavery out of its domain—which is a puzzling outcome.[7] Is this because there were no environment endowments suited to free soil in the slavery-legal region? We begin by seeking to measure which environmental conditions generated "success" under each institutional regime.

II. Calibration of Suitability Indices

The key suitability variables that we seek to predict at the county level is rural population density. We also examine, in the South,the fraction of the population enslaved, and slave

[6] Easterlin (1961, p. 256) placed Delaware and Maryland in the Mid-Atlantic region and Missouri in the West North Central region. Fogel-Engerman (1974) and Lindert-Williamson (2016) followed suit. To calculate the income share of the slave South, we attribute to the populations of these states the per capita incomes of their assigned regions and include the resulting total income with the South.

[7] A long-standing policy of some Whigs (e.g. Henry Clay) and later many Republicans (e.g. Abraham Lincoln) was to contain the slave system from expanding on the frontier, not to rollback.

population density.[8] For rural population density, we develop separate calibrations in the slavery-legal and free-soil regions. These two measures, which may be taken as suitability indices for settlement under the two regimes, will differ if the institutions have different marginal values for endowments. We estimate for each system, r, over a sample of counties, i, operating under the system, the following specification:

(1) $Density_i = \varphi_r(\text{Ecological Endowments}_i)$.

The second set of measures -- the fraction of the population enslaved and slave population density -- may be treated as suitability indices for slavery. These indices, estimated in a specification analogous to (1), will necessarily be calibrated only in the slavery-legal region. We apply estimates of the relationships from that region to a more comprehensive sample of counties. There is sufficient internal variation in the prevalence of slavery within the slavery-legal region and sufficient commonality in environmental conditions between the slavery-legal and free-soil regions for this to be a meaningful exercise. But care must be taken to avoid extrapolating far from the common support of the data.

We use the voluminous ecological data described in Bleakley and Rhode (2022) to estimate settlement suitability indices in what we conceive to be a comprehensive and methodologically transparent manner.[9] The variable list is as follows:

[8] Due to data limitations, the slave population density is for the entire county, including both rural and urban areas.

[9] The indices include longitude but not latitude. The ecological variables do not alone capture the unfolding of the settlement process, which largely proceeded from east to west. Including longitude captures these effects without incorporating endogenous variables such as the date of county formation.

1. General variables

Elevation: mean and std. dev.

Longitude (not but latitude)

Slope: mean and std. dev.

Aquifer

On river, excl. Ohio & Miss.

Karst

Earthquakes (count)

Seismic Hazard (g)

2. Weather variables

Temperature (8 mo.): mean and std. dev.

Rainfall (8 mo.): mean and std. dev.

3. Soil variables, at various depths

Available water capacity

Bulk density

Fractions of clay, sand, and silt.

k−factor

pH

Porosity

Depth to bedrock

We combine these ecological data with a cross-validated shrinkage estimator to generate indices of suitability for slavery and settlement under the two systems. Using shrinkage instead of OLS helps address the concern that when we fitted a prediction equation to one dataset and apply them to a second dataset, we will over-fit and make the estimates too sensitive to select variables in the first dataset due to the sampling. This will lead to higher variance in the predicted values in the second dataset. This concern is especially salient as we are using a large number of ecological variables as predictors. We specifically use Ridge, which penalizes large coefficients. This introduces some downward bias in the coefficients in order to reduce prediction variance.[10]

We calibrate the indices on the counties in each region within 300 miles of the border. In addition to the default specification of a. the shrinkage estimator run on geographical variables and a quadratic in the weather variables, we also run the following alternative specifications: b. the shrinkage estimator run on weather interacted with all of the geographical variables; and c. an OLS estimator on geographical variables and a quadratic in the weather variables. (Later in the analysis we will use leave-one-out estimators.) We then applied the prediction equations φ to the entire sample, hence extrapolating the suitability indices calibrated from one region into the other.

[10] We use Stata's "elasticnet" command, which allows for a mix of ridge regression and LASSO. We tried various mixes until choosing to set alpha equal to zero, which gives ridge regression. In preliminary work, we found that LASSO typically did not seek to exclude any of the variables, which undercuts the purpose for employing that procedure.

III. Extrapolations of Suitability Indices

The endowments that supported successful settlement in one region were present in the other. But institutions do value endowments differently. Figure 2 maps the predicted values of rural population density. Panel A denotes the prediction calibrated to the free-soil region whereas Panel B uses those calibrated to the slavery-legal region. Both the similarities and the differences are interesting. The similarities capture the locations that would be densely settled under either system; the differences show the locations favored in one system and not the other. In neither panel is there a sharp break at the border, indicating that policy choices about institutions rather than environmental conditions account for the differences in actual outcomes.

According to the indices, free-soil institutions could have succeeded far south of the free-slave border. The shading of the maps is set to the same scale, so Panel A displays a denser rural population than Panel B. Panel C graphs the predicted values against one another. Most of the points are below the 45-degree line (of equal indices under the two systems). This reveals that (a) the institutions valued the endowments differently and that (b) in most counties, the predicted population density would have been higher under the free-soil regime than under the slavery-legal regime. Panel D conducts the same analysis for states (excluding those far from the border). Again, most states are below the 45-degree line. Iowa is one exception, which perhaps points to the source of the conflicts over the Kansas-Nebraska territory. (Abraham Lincoln was, based on this evidence, right to dismiss the claims of Stephen Douglas that nature excluded slavery from much of the West.)

Figure 3 maps the predicted distribution of the enslaved population. Panel A maps the predicted density per unit area whereas Panel B maps the predicted fraction of the population enslaved. These exercises allow for counterfactual assessments of where, for example, slavery would have been prevalent within the free-soil states were it legal. Note the distributions do not consider limitations on the existing size of the enslaved population in 1860 nor of the effects of the hypothetical expansion of the domain of the peculiar institution on slave prices. The region around Toledo, Ohio appears a potential hotspot for slavery; it shared environmental characteristics with the parts of the South where slavery was prevalent. As above, there is no clear break in the predicted values at the actual free-slave border.

Another way to visualize the suitability of free-soil agriculture is Figure 4, which plots each county's free-soil index for rural population density versus the distance to the free-slave border. To separate the regions, free soil areas have a negative distance in this graph. Each county is a dot (proportioned to county area) and the gray line is a quadratic fit in distance, for the region where slavery was legal. Panel A shows the default calibration (from a cross-validated ridge regression with ecological variables and a weather quadratic). The index is a predicted value throughout, but everything to the right of zero is predicted out of sample. South of the border, the distribution of the index is at least as good as on free soil over a rather large range. The peak itself is at almost 300 miles, which is well into the Deep South.

Allowing for interactions of climate and geology does not alter the conclusion of high free-soil suitability in the Upper South. Presumably a geological variable (e.g. sandy soil at a certain depth) has a different hedonic value if the climate differs. To check this, we recomputed the index with interactions between the weather quadratic and each geological variable. (This estimation has around 500 variables now, so shrinkage is even more important.) Panel B contains a plot of the new index. If anything, the distribution of outcomes in the Upper South looks higher and the quadratic fit peaks farther south.

We obtain a similar result using OLS to construct the index on the default set of variables. (A few variables are dropped, per Stata's algorithm, for collinearity.) This index shows the possibility of successful free-soil agriculture in the Upper South. The quadratic fit, however, peaks closer to zero, and the index is lower for the Deep South than before.

We can also focus our inference to Southern counties within the support of the ecological variables in the North. This is a restrictive criterion that ignores a county if any of the more than four-score variables lies outside the range measured for free soil. Essentially all of the counties in the Deep South are excluded. In Panel D, we flag the retained observations with gray dots and estimate the quadratic fit for those alone. (These are the same values displayed in Panel A.) The gray dots tell the same story: there was ample room for free-soil agriculture in the Upper South.

Do the rural density indices created for 1860 apply to earlier periods as well? We can readily carry out the same estimation procedure for 1850 and the results are close.
The correlation for the indices calibrated to the free-soil regime in the free-soil sample between 1850 and 1860 is 0.907. For the whole sample, the correlation is 0.904. The correlation for the indices calibrated to the slavery-legal regime for the slavery sample between 1850 and 1860 is

0.671. For the whole sample, the correlation is 0.270. For both indices, the correlations were higher in the sample in which the indices were fitted than in the sample in which they were applied. And the correlation between the indices under the same regime over time is much higher than the correlation between the indices calibrated to the free-soil and slavery-legal regimes at the same point in time. (The correlation of the free-soil and slavery-legal indices in the whole sample is 0.437 for 1860 and 0.187 for 1850.) It is reasonable then to focus on the 1860 indices and learn what we can in detail.[11]

IV. Returns to Endowments

The endowments associated with successful settlement in one region were not highly valued in the other. In the North, this should be no surprise, as slavery was banned. In the South, however free farms were permitted. Indeed, they represented the majority of agricultural operations.

We estimate the (hedonic) returns to each of the region-specific settlement indices. The outcomes include rural population per county area, farm value per county acre, farm value per total farm acres, total farm acres per county area, improved farm acres per total farm acres, the slave fraction of the populations in levels and again in log odds.[12]

How do the settlement indices predict the outcomes when used together in the same regression? Consider the following model:

$$(2)\ Y=\beta_{free}\,\varphi_{free} + \beta_{slave}\varphi_{slave} + \text{Spatial Controls}$$

Model (2), including the "own" and "other" settlement suitability indices, is analyzed in Table 1. The results for the free-soil states appear on the left, columns (1)-(5) and those for the slavery-legal states appear on the right, columns (6)-(12). The baseline is for the counties in a 300-mile buffer of the free-slave border. The spatial controls are a cubic in distance from the border and a cubic in longitude. As a way of focusing attention, Figure 5 displays the regression coefficients for a key outcome, farm values per county area, columns (2) and (7), over the different specifications. Appendix Table 3 replicates Table 1 for the indices calibrated with OLS instead of Ridge.

[11] Appendix Tables 1 and 2 relate the suitability indices to the outcomes in the border paper (Bleakley and Rhode 2022).

[12] The first outcome, rural population density, is used to construct the settlement index. To avoid inference problems, we re-estimate the index for each county leaving out its own observation.

Table 1, Panel A presents results when only the own regime's index is included. The results consistently show strong effects of the expected sign. Panel B presents results when only the other regime's index is included. For the Free-Soil states, the results for the slavery-legal index are always small and statistically insignificant. For the Slave states, the results for the free-soil index are small—smaller than for the own index—and statistically insignificant for most variables.

Panel C includes both indices in combination, and the own-region index dominates. For the Free-Soil states, the results for the free-soil index are always strong and statistically significant whereas those for the slavery-legal index are always small and statistically insignificant. There is a similar pattern with respect to the own and other indices in the Slave states. To take column (7) on farm value per county acre as an example, the coefficient on the own index is close to unity whereas that on the other index is of very small magnitude (indeed, negative but insignificant). The only meaningful exception to this pattern occurs in column 6 on rural population density where the coefficient on the free-soil index is positive and statistically significant, if small in magnitude. It is not surprising that the environmental conditions that predicted higher population density in the free-soil region had positive effects in the slavery-legal region even controlling for the slavery-legal settlement index. Free farming was legal in the South and slavery was uncommon in many counties in the southern states. What is surprising is that the effects are not stronger. Column (10), on the improved land share, again echoes the results of column (6).

Panels D-H present a series of robustness checks, altering the spatial controls, including interactions with temperature and rainfall, leaving out the county's own state in calibrating the index, narrowing the sample to a 150-mile buffer, and broadening the sample to cover all counties. Again, the own index matters much more than the other index.

The final two columns present a selection equation: what predicts which mode of production is used? (Such an equation is the first component of the Roy model of selection.) The simple logic of the equation is that a farm chooses the mode of production with the highest value. The indices are county-level indicators of the value of each mode of production, to which we add idiosyncratic productivity shifters for each piece of land within the county. Call the former φ_s and φ_f and the latter ε_s and ε_f. Let $\varepsilon = \varepsilon_f - \varepsilon_s$ and let ε be distributed $f(\varepsilon)$. The probability of choosing slave-based agriculture is $P(\varphi_s - \varepsilon_s > \varphi_f - \varepsilon_f)$ or $P(\varphi_s - \varphi_f > \varepsilon_f - \varepsilon_s)$. The partial derivative of P w.r.t. φ_s is $f(\varphi_s-\varphi_f)$, which is the negative of the partial w.r.t. to φ_f. A regression of the fraction slave on the indices should yield coefficients of the same magnitude and opposite sign. In this specification, dirt is dirt and overarching institutions do not matter. Instead, if free farming is suppressed by the institutions that prevail where slavery is legal, the coefficient on φ_f would be attenuated relative to φ_s. For example, suppose the selection equation is ($\varphi_s - \varepsilon_s > \alpha_0 + \alpha_1 (\varphi_f - \varepsilon_f)$), for $\alpha_0 <0$ and $0<\alpha_1 <1$. Then the partial on φ_f would be lower than on φ_s. In the special case that ε is distributed logistically, the indices predict the log-odds of proportion slave directly, without reference to $f(\varepsilon)$. Table 2 presents estimates for the slave fraction of the population, both as a level and as the log odds ratio.[13]

In our estimates of this selection equation, the usual logic of comparative advantage is halfway broken. The coefficient on the slavery-legal index is always positive and significant, as expected. However, the coefficient on the free-soil index is not of equal magnitude and opposite sign. Indeed, the estimates are usually positive. They are rarely significantly different from zero, but usually we can reject the theoretical prediction of opposite values.

This result indicates a near-complete discounting of the role in free-soil suitability in determining the mix of modes. It is as if planters pick the good land for slave-based agriculture and free farmers had what was left over. Indeed, this is precisely the allegation of Hinton Helper (1860, p. 181, emphasis added): slaveowners "have, *as the result of a series of acts of their own villainous legislation*, become the sole […] proprietors of almost every important item of Southern wealth; not only do they own all the slaves — none of whom any really respectable person cares to own — but they are also *in possession of the more valuable tracts of land* and the appurtenances thereto belonging."[14] Helper quotes a Missourian who states "non-slaveholders possess, generally, but very small means, and the land which they possess is almost universally poor, and so sterile that a scanty subsistence is all that can be derived from its cultivation; and the more fer-

[13] The logistic distribution is close to the normal. We could assume that ε is normally distributed, but this would not allow for a linear specification. Rather it would have to incorporate the nonlinearity of $f(\varepsilon)$ in this case:

$$s = \beta \exp(-(\alpha_0 + \alpha_1 \varphi_f - \varphi_s)^2) (\alpha_0 + \alpha_1 \varphi_f - \varphi_s)$$

in which the β contains both the effect size itself and the problem-specific constants associated with the normal distribution. If we estimate this equation (plus spatial controls) with nonlinear least squares, we obtain an α_1 of 0.158 (std. err. 0.037), which represents a large markdown of the influence of free-soil, relative to slavery-legal, indices.

[14] Helper added that the poor whites of the South were "indescribably wretched tenants of these slavocratic land-sharks" (p. 150) in a "second degree of slavery" (p. 24) maintained by state governments that did not represent their interests and that the institution of slavery was "forcing the more industrious and enterprising natives of the soil to immigrate to the free states" and "preventing foreign immigration" (p. 32).

tile soil, being in the possession of the slaveholders, must ever remain out of the power of those who have none" (p. 164).

We now examine the returns to endowments interacted with the local prevalence of slavery. Consider an alternative model (3) with interaction terms:

$$(3)\ Y=\beta_{free}\ \varphi_{free}\,(1\text{-}s) + \beta_{slave}\ \varphi_{slave}\ s + \text{Spatial Controls}$$

where s is the fraction of the population enslaved. Model (3) is in the spirit of a Roy model of selection. This is run only in the slave states, in the counties in the 300-mile buffer of the border. The results are reported in Table 2. The free-soil index should matter more in the counties where the fraction slave, s, is smaller and the slavery-legal index matter more where s is higher. As s is endogenous in the model under consideration, we supplement the OLS analysis of Panel A with a 2SLS analysis in Panels B-F, where we instrument for the fraction enslaved in various ways.

In the OLS regressions of Panel A, the slavery-legal settlement index interacted with the fraction slave has strong, statistically significant coefficients of the expected signs. The free-soil settlement index interacted with the fraction free has statistically significant, positive but small coefficients for rural population density and the improved land fraction. But the term has insignificant impacts on the other outcomes.

In the 2SLS regions of Panels B-F, the slavery-legal interaction terms are always strong, statistically significant and of the expected positive sign. The free-soil interaction terms are now always small and statistically insignificant. What is notable here is that conditions that predict success in the free-soil region do not generate success in the slavery-legal region, *even where slavery is not commonly used*.

A few comments about the various 2SLS specifications are in order. As mentioned, the fraction of the population enslaved is endogenous, but we take the ecological indices as exogenous and excludable. In Panel B, we use a quadratic in the rural-density indices as instruments. For Panel C, we add the indices for slave fraction and population density as instruments. A remaining concern is that this estimator embeds a selection problem within it. The issue is that the mode-specific error term is correlated with the outcome, when that mode is chosen. This attenuates the coefficient under standard assumptions. Our estimates for β_{free} are generally negative, so we do not worry about missing large, positive effects for the own bias.[15]

Finally, we find similar results after tweaks to the calibration or to the estimation sample. In Panel E, we re-run the models in Panel B, but with indices that used interactions of geological and climate variables, as in Panel B of Figure 3. For Panel F, we use the entire region where slavery was legal in the estimation of Model (3).

In Appendix Tables 4 – 7, we present results similar to those in Table 2, but with a few alternate assumptions. First (App. T. 4), we rerun the analysis with indices calibrated by OLS instead. The results are similar, although the coefficients tend to be smaller. The free-soil coefficients are essentially zero if the index is calibrated to the variables and their interaction with climate. This is to be expected as the overfitting problem would be more severe in this case, and thus the index would be a poor predictor out of sample. Next (App. T. 5), we include controls for the fraction of the county's land in the Public Land Survey System (PLSS) and its interaction with the rural- density indices. We alternately (App. T. 6) include controls for the fraction of the county's land north of the terminal (glacial) moraine and its interaction with the rural-density indices. Finally (App. T. 7), we use OLS and the calibrated index for slave population fraction instead of the realization in the regressions, which obviates the need for 2SLS. These results are generally similar: positive and significant coefficients on the slave-legal index for rural density, but much smaller coefficients for the free-soil index.

In summary, the counties in the North with a comparative advantage under the free-soil regime enjoyed a boost in rural population density and farm values. The counties in the South with a comparative advantage under the slavery-legal regime also enjoyed a boost. But those Southern counties with a comparative advantage under free-soil regime did not enjoy anything near the benefits that comparable counties in the North did. Farming with slaves in the North was prohibited, so we would not expect comparative advantage in slave-based agriculture to go unrewarded there. But free farming was perfectly legal in the slave states, so free-soil opportunities should have been rewarded. We turn to microdata on free farms to understand this puzzle.

V. Micro-Data on Farms

[15] The standard approach to correcting this would be to model the choice with logit or probit and use conditional expectation of the error term as a control. Here this would be inappropriate as there are counties with zero slaves.

Based on the settlement suitability indices, the free-soil regime could have succeeded much further South. The border South, in terms of its endowment, looked as attractive or more attractive than the border North. The shares model (Model 3) reveals that southern counties, even with the environmental conditions conducive to free-soil success, did not prosper in terms of rural population density or farm values. But how did free farms actually fare in the slavery-legal region?

Here we go beyond the existing economic history literature (see, for example, Craig and Field-Hendre 2004). This literature compared the rural North—as reflected in the Bateman-Foust (1976) sample—with the Cotton South—as reflected in the Parker-Gallman (1991) sample. Instead, we compare Kentucky farms with only free household members with those in the state with enslaved members, and with farms in states across the Ohio river. The exercise requires that we collect a new micro-sample of Kentucky farms from the agricultural census of 1860, link these observations with the families reported in the population census, and with the schedules of the slave census (FamilySearch.org, 2023).[16]

We picked 30 pairs of pages at random from the Kentucky agricultural schedules. Figure 6 maps the counties covered and compares our sample to the Bateman-Foust sample for Ohio, Indiana, and Illinois. Each pair of pages that we drew included up to 80 observations. We record the farm data. The main variables of interest are (a) Acreage (improved and unimproved); (b) Cash value of farm (not just land); (c) Value of implements and of livestock; and (d) Crop output and animal products.

We then manually link the listed owners/operators manually to the population and slave schedules. From these records, we measured potential family and slave labor on the farm. Searching for farm operators in the census population schedule was facilitated by several factors, namely that the agriculture and population schedules were taken (a) in most cases, by the same enumerator; (b) often in the same order; and (c) sometimes on the same day.[17] The linkage rate

[16] Several scholars – Schaeffer (1978a, 1978b), Irwin (1988), McKenzie (1994), and Dunaway (1996) —collected linked micro samples partially covering the border South before the age of the micro-computer. Most are lost now; only Irwin's sample for the Virginia Piedmont is available as digital micro data. We thank James Irwin for sharing his data.

[17] Within our transcription spreadsheet and for each farm operator, we coded a link that opened up the relevant search page (keyed to name, location, and census year) in familysearch.org. Such a search was frequently unnecessary, however. Once we found a match, the next farm owner on the agricultural schedule was often in the following few households on the population schedule. In other work using automated record linkage from a larger sample of farm owners to the population schedule, we find a high degree of structure relating the location on each schedule (Bleakley and Rhode, 2023c). This validates our use of proximity in the schedules as part of the manual linkage process.

between the farm and population schedules was an impressive 98 percent. The linkage rate to the slave schedule was lower, less than 30 percent, which is consistent with slave ownership rates.

The resulting sample includes 1,979 Kentucky farms. We break the Kentucky farms into those with and without slaves. We compare these two subsamples with free farms operating North of the Ohio River—in Ohio, Indiana, and Illinois—as recorded in the Bateman-Foust sample.

The panels of Figure 7 compare the frequency distributions of these three samples for several key variables. For Improved Acres per Farm (Panel A), the Kentucky farms with slaves were much larger, on average, than the free Northern farms, which were slightly larger than the Kentucky farms without slaves. For Farm Value per Improved Acre (Panel B), the rank order was the same, but the distributions were more spread out. The distribution for Kentucky farms without slaves lay far to the left of the distribution for free Northern farms.

We take the output data (including crops and animal products) from the census of agriculture, remove seed requirements, apply local prices and sum to generate the value of farm's total output. A notable finding emerges if the output value is divided by farm values (see Panel C.) The Kentucky farms without slaves have much higher ratios of crop output to farm values than either of the comparison groups. Table 3 reports coefficients for farm-type dummies in regressions explaining the log of the value of farm output to farm values. The omitted category is Kentucky slave farms.

We can break up the ratio and seek to determine whether the gaps between free and slave farms in Kentucky were due to differences in location. Figure 8 reports the coefficients as we move to ever tighter comparisons-- from the whole state, to census pages (column two), to one-half census page, to pairs (column eight). The last comparison, involving slave farms next to free farms on the same census page, is quite sparse, and the standard errors grow large. The one-half page comparisons represent near neighborhoods in the census and may be used as a baseline sample to control for local geography. In Table 3, the regressions with one-half-page fixed effects, show Kentucky free farms had ratios of crop output to farm values over 40 percent higher than Kentucky slave farms.

In summary, slave farms in Kentucky were larger than the farms in the comparison groups. Free farms in Kentucky were of lower value per acre than the comparison farms. More notably, the free farms had higher output per farm value. These differences mostly survive controlling for local circumstances.[18] The value ratios are consistent with the slave farms buying up the better lands, as Hinton Helper (1857) argued. But the results also show that the free farmers required higher output values per dollar invested. This could be a compensating differential for operating in a disadvantageous environment. The premium also indicates that those who remained were not simply unproductive losers who could not make anything of their efforts, as Alexis DeTocqueville (1838) suggested in his discussion of Virginians.

While the difference in gross land return might seem large, it is, in fact, consistent with other evidence on regional wage differences. In our analysis of the borderlands, we concluded that wages (for hired labor, of course) were higher on the side where slavery was legal. In addition, we found that land prices were lower on the side with slavery. Nevertheless, we document that the free population had a much higher propensity to be on the side of free soil, where the real wage was lower. Taken together, these facts indicate that free labor associated a significant disamenity with being where slavery was legal. We estimated the real wage premium to be approximately 9 percent.

How would this compensating differential manifest in the data for farmers? These farmers do not earn a wage, but the opportunity cost of their time must be covered by their proprietor's income, otherwise they would change location. So, we would expect the implicit value of labor to also be about 9 percent higher for free farmers in slave states, as compared to those on free soil. Would this be the case? Consider the total cost and revenue of the farm and assume perfect competition, so revenue equals cost in equilibrium. Take the land share in farm production to be 10 percent and the labor share to be 50 percent. (See Bleakley and Rhode, 2023b, for sources.) This means that the 40 percent higher gross land return opens up 4 percent gap between revenue and costs. If the farm is a price-taker for non-labor inputs, then then this 4 percent gap goes to (implied) labor compensation. This is half of cost, so the gap increases the implied wage by 8 percent. This is quite close to the other estimate of 9 percent. We conclude that the land premium is well explained by a compensating differential that free farmers have to receive for their labor. To stay in Kentucky, they need a higher land return of exactly this amount.

[18] Other notable results in the sample are (a) no difference in mules vs horse holdings for free vs. slave operations; (b) about half of tobacco in Kentucky sample was produced on farms without slaves. See also Schaefer (1978b).

We can conduct a similar analysis within the Parker-Gallman (1991) sample of farms and plantations in cotton-producing counties in 1860.[19] In these counties, about one-half of the farming operations were free and one-half slave; slave operations had significantly more land than free farms. And it was the more valuable land, even controlling for locality. That is, we can regress the log of farm value per acre of land (improved plus unimproved) and the log of output per farm value on an indicator variable for the absence of slaves on the farming operation with fixed effects for the specific locality, for the cluster of observations. (Recall Parker and Gallman's, 1991, sampling design involved collecting five names in a cluster from the middle of the page in the manuscript Census of Agriculture. The inclusion of fixed effects here controls for the page from which the cluster was drawn.) Table 4 shows the regression results. As above, free farms in the Parker-Gallman sample were of lower value per acre and generated higher value of output per farm value than neighboring slave operations. This confirms the findings in the Kentucky sample, although the magnitudes are smaller.

We next turn to Irwin's (1988) sample from the Virginia Piedmont, and we obtain similar results. His sample is at a similar latitude to ours in Kentucky, although he zooms into a more homogeneous subregion. The Piedmont region is between the Fall Line and the Appalachians Mountains, so it had excellent transport access going out, but less so going in. The main export crops were tobacco and wheat. In Table 4, we see the regression results. (Irwin used a similar sampling strategy to Parker and Gallman.) Within that region, free farms had lower value land per acre and higher output per land value. The magnitudes lie in between those for Kentucky and for the cotton counties.

VI. Commentary

The inhibiting effects of slavery on the economic performance in the border South had long been the subject of commentary. In a speech to the Virginia House of Burgesses in 1759, Richard Henry Lee inquired: given "some of our neighbouring colonies, though much later than ourselves in point of settlement, are now far before us in improvement, to what, Sir, can we attribute this strange, this unhappy truth?" The cause was not the environment, Lee asserted: "Nature has not particularly favored them with superior fertility of soil, nor do they enjoy more of

[19] Here we gauge farm output as the value of all crops (at national prices) and the reported value of animal slaughtered. The national crop prices for 1860 are from Towne and Rasmussen (1960, pp. 255-316). We did not include the value of orchard or market garden products or of home manufacturing.

the sun's cheering influence, yet greatly have they out stripped us." Instead, he opined: "The reason seems to be this: that with their whites they import arts and agriculture, whilst we with our blacks exclude both." His suggested remedy was legislation "to lay so heavy a duty on the importation of slaves, as effectually to stop the disgraceful traffic." (See Moore 1857, p. 41).

Reverent Jonathan Boucher (1797, pp. 38-43), an Anglican minister from Virginia, also asserted that the Upper South was lagging behind the Middle colonies, although the latter began to settle much later. He blamed the institution of slavery, which introduced a labor force without incentives to improve and turned their owners into worse people.

In 1821-23, George Ogden (1907, pp. 111-12) wrote: "No part of the country possesses a more a salubrious climate or better soil, than the extensive state of Virginia; yet her white population is comparatively small. Kentucky is likewise a slave-state; her population is considerable, but it is owing to many adventitious circumstances, and accidental causes, which are not difficult of explanation. — The state of Ohio is in its infancy; slavery is excluded from it; and even colored people cannot reside here except under certain regulations. This will induce a rapid population, augment her number and resources, and she will be soon able to rise superior to her sister states in every point of view."

In 1832, during Virginia's debates over slavery in the aftermath of Nat Turner's Rebellion, Charles J. Faulkner (1832, p. 20) observed:

> If this should not be sufficient, and the curious and incredulous enquirer should suggest that the contrast which has been averted to, and which is so manifest, might be traced to a difference in climate or other causes distinct from slavery itself, permit me to refer him to the two states of Kentucky and Ohio. No difference of soil no diversity of climate no diversity in the original settlement of those two states can account for the remarkable disproportion in their national advancement. Separated by a river alone, they seem to have been purposely and providentially designed to exhibit in their future histories the difference which necessarily results from a country free from and a country affected with the curse of slavery. The same may be said of the two states of Missouri and Illinois.

In his Address to the people of west Virginia, Henry Ruffner (1847, p. 15), a slave-owner and opponent of the institution of slavery, opined:

> There are certain drugs, of which large doses are poisonous, but small ones are innocent or even salutary. Slavery is not of this kind. Large doses of it kill, it is true; but smaller doses, mix them as you will, are sure to sicken and debilitate the body politic. This can be abundantly proved by examples. For one, let us take the rich and beautiful State of Kentucky, compared with her free

> neighbor Ohio. The slaves of Kentucky have composed less than a fourth part of her population. …. This wonderful difference could not be owing to any natural superiority of the Ohio country. Kentucky is nearly as large, nearly as fertile, and quite equal in other gifts of nature….
> Ohio is by this time considerably more than twice as thickly peopled as Kentucky; yet she still gains both by natural increase and by the influx of emigrants; while Kentucky has for twenty years been receiving much fewer emigrants than Ohio, and multitudes of her citizens have been yearly moving off to newer and yet newer countries.

Ruffner (1847, p. 17) continued:

> Many of these multitudes, who have left the slave States, …settled in the free countries of the West. These were generally industrious and enterprising white men, who found by sad experience, that a country of slaves was not the country for them. It is a truth, a certain truth, that slavery drives free laborers—farmers, mechanics, and all, and some of the best of them too—out of the country.… Some go because they dislike slavery and desire to get away from it: others, because they have gloomy forebodings of what is to befall the slave States…: others, because they cannot get profitable employment among slaveholders: others, industrious and high-spirited working men, will not stay in a country where slavery degrades the working man: others go because they see that their country… does not prosper, and that other countries, not far off, are prospering, and will afford better hopes of prosperity to themselves.

Many similar statements were made for other parts of the border South (Tallant 2005; Stampp 1944).

Northerners also expressed opinions. In the debates over the expansion of slavery onto the territories conquered from Mexico, the Pennsylvania congressman David Wilmot (1847) proclaimed: "Where the negro slave labors, the free white man cannot labor by his side without sharing in his degradation and disgrace." And in his Peoria speech, in which he resumed his political career, Abraham Lincoln (1854) stated: "Whether slavery shall go into Nebraska, or other new territories, is not a matter of exclusive concern to the people who may go there. The whole nation is interested that the best use shall be made of these territories. We want them for the homes of free white people. This they cannot be, to any considerable extent, if slavery shall be planted within them. Slave States are places for poor white people to remove FROM; not to remove TO. New free States are the places for poor people to go to and better their condition. For this use, the nation needs these territories."

William Seward (1858), in his famous "Irrepressible Conflict" speech at Rochester, New York, added: "In states where the slave system prevails, the masters, directly or indirectly, secure all political power, and constitute a ruling aristocracy. In states where the free-labor system prevails, universal suffrage necessarily obtains, and the state inevitably becomes, sooner or later, a republic or democracy."

VII. Conclusion

Free Soil was not just magic dirt, at least in the sense that the magic lay not in the literal dirt or endowments. Rather, Free Soil was the set of institutions that arose in the Northern states where slavery was prohibited (Foner 1970). As noted by many antebellum politicians and later observers, these institutions seemed materialized from the Jeffersonian dream of yeoman farmers with the opportunity to rise economically and participate politically and to take responsibility for their own fortunes (Gates 1976; Edwards, Fiszbein, and Libecap 2022). Such small holders would be suitable for both economic and political agency, in contrast with the widespread patterns of social exclusion in most of the world. To be sure, not everyone was included in this invitation. But that the legal systems favored the widespread participation within that group. In this way, it was unusual. This vision found reality in the Northwest Ordinances, which opened those frontier territories for settlement as free soil.

In the Antebellum United States, both population and economic activity grew more rapidly in the free-soil region than in the slavery-legal region. In 1860, population density and real estate values per acre were higher in the free-soil region than in the slavery-legal region, both locally (close by) and globally (over the entire regions). Yet the free-soil regime was not pushing slavery out of its own domain. Is this because the environmental endowments suited to free soil were absent in the slavery-legal region? No, we show the endowments were similar. The different outcomes arose from the operation of the different institutions. Free-soil endowments had low returns where slavery was legal. And turning from ecological analysis to newly collected farm-level data, we show free farmers in the border South operated on less valuable land and generated more output per dollar invested, in line with requiring a compensating differential to operate there. Free farming was legal in the South and indeed most southern agricultural operations were free-labor farms. And yet the areas in the South suited to the free-soil regime appear to have fallen under the developmental shadow of slavery. "Plain folks" existed in the South, as Frank Owsley (1949) asserted, but they did not exert the same demand for land as they did in the free-soil North.

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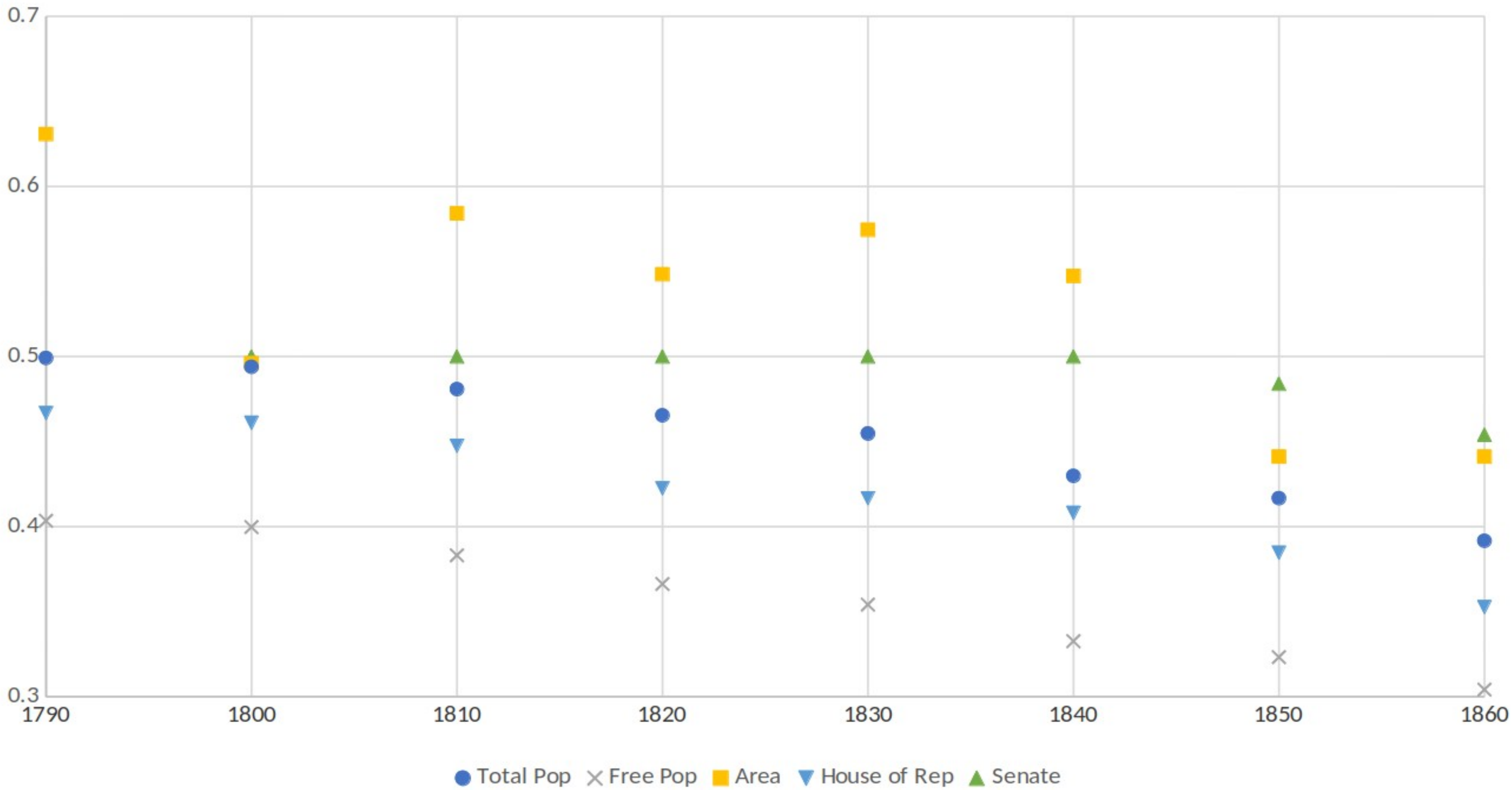
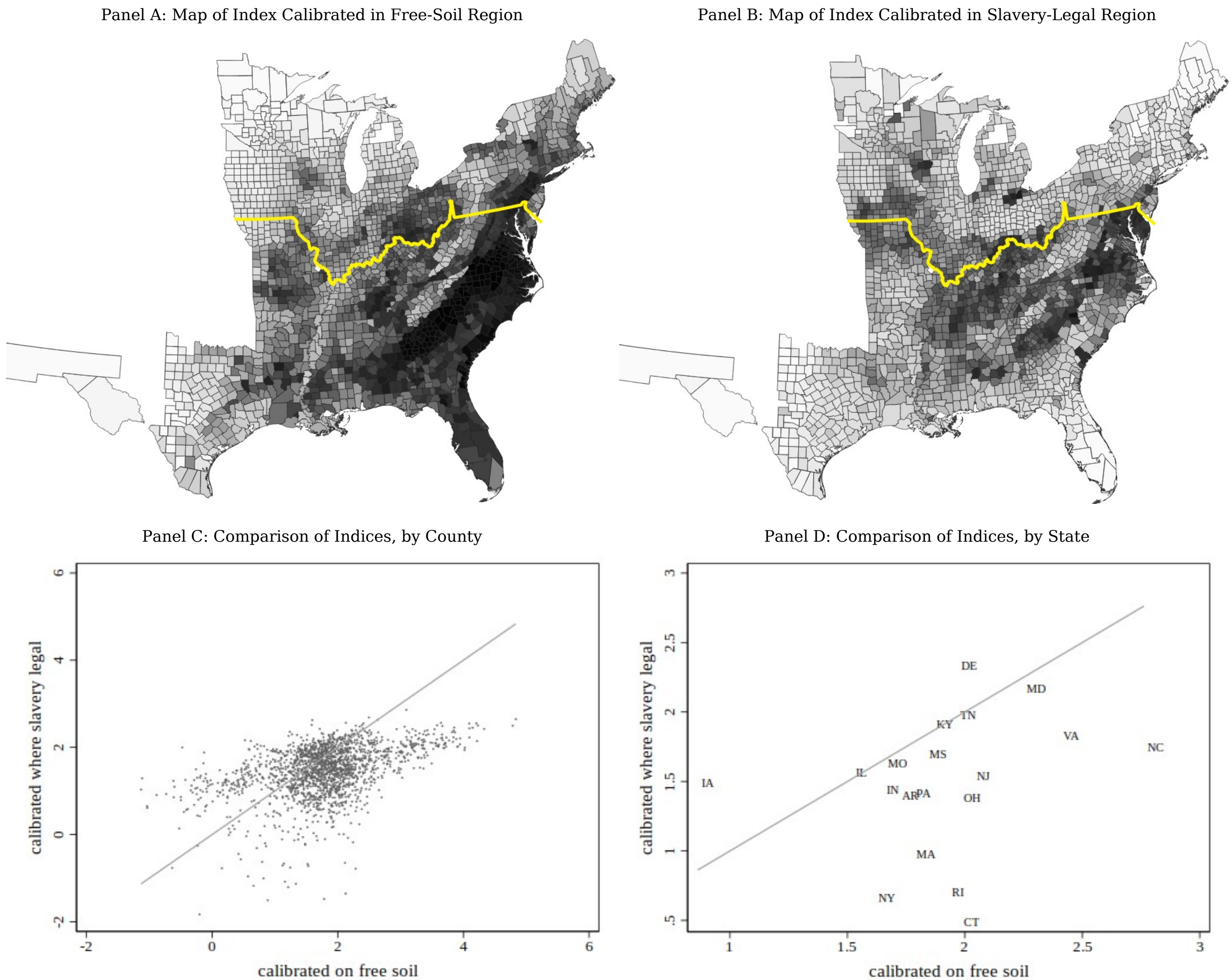
Figure 1: Southern Shares on National Population, Land, and Political Representation, 1790-1860



Sources: Historical Statistics of the United States, Mill. Ed. Series Eb3 (politics); Bicent. Ed. A195 (pop), A210-262 (territory), and authors' calculations.

Figure 2: Ecological Indices for Rural Population Density, 1860

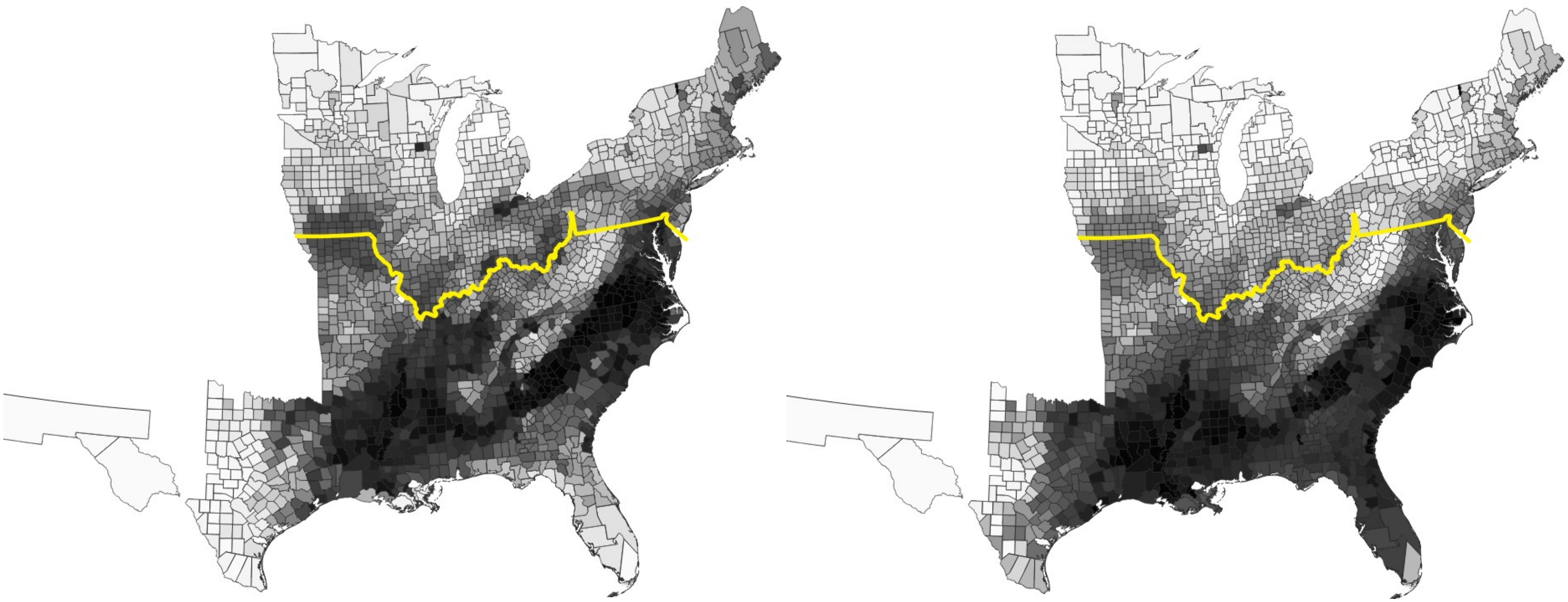


Notes: These graphs display ecological indices for rural population density in 1860 using different regions for calibration. In the upper two panels, these data are mapped by county using NHGIS boundaries, with the border between free and slave states drawn as a reference. Panel C is the scatterplot comparing rural-density indices calibrated in each region, with the 45-degree line as well. Panel D is similar to Panel C, but with area-weighted state averages displayed instead, each denoted by the state abbreviation. Data sources and variable definitions are described in the text.

Figure 3: Ecological Indices for Slave Population Share and Density, 1860

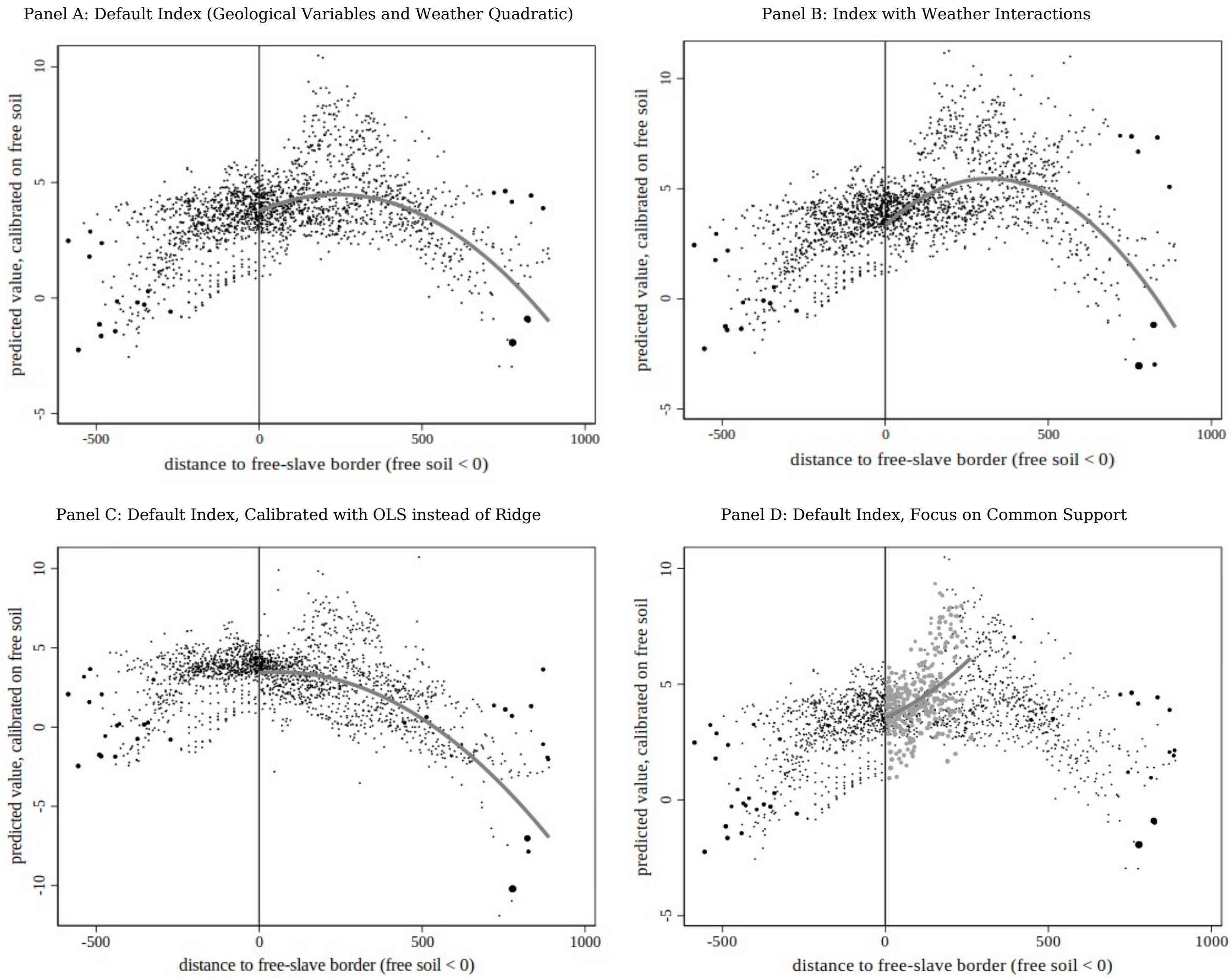
Panel A: Map of Index Calibrated to Density

Panel B: Map of Index Calibrated to Population Fraction



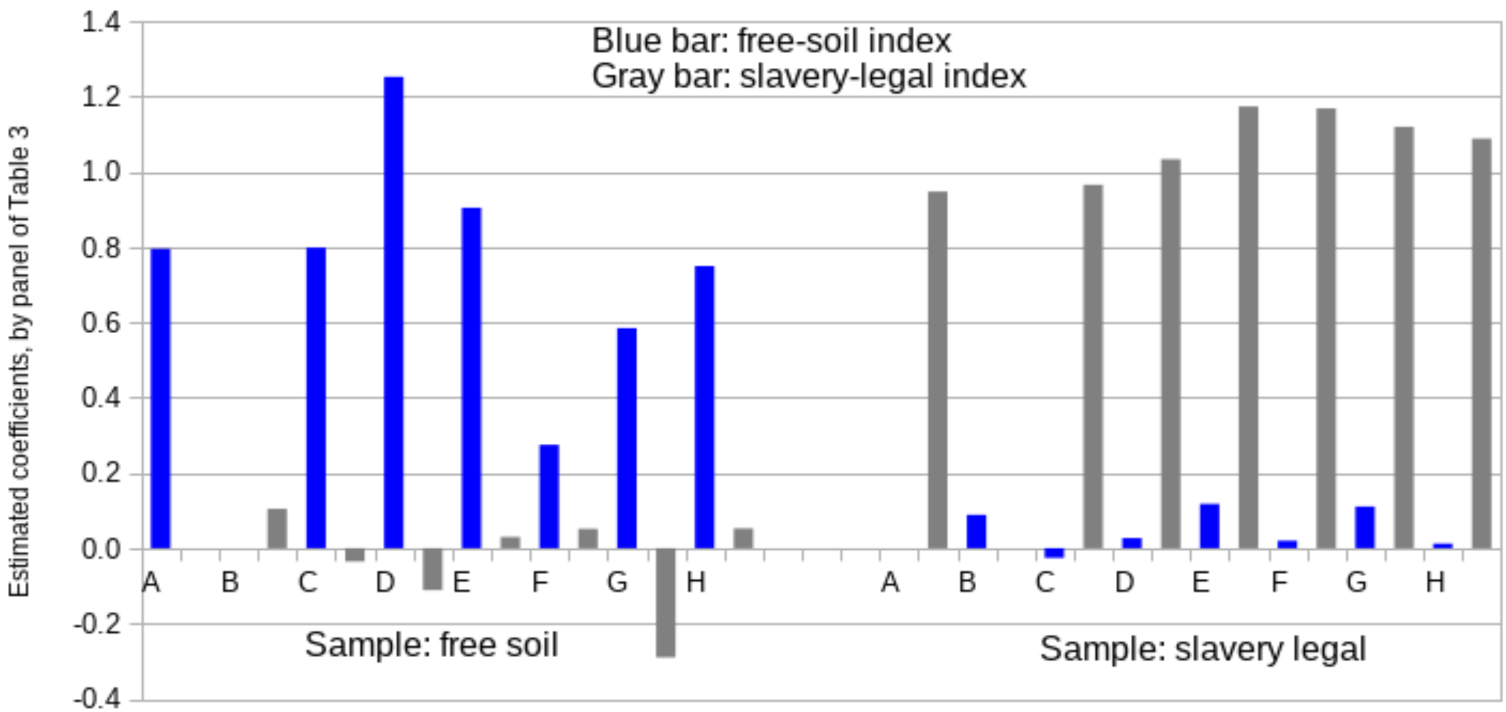
Notes: These maps display ecological indices for the of slavery by 1860 county. These are calibrated to the region where slavery was legal, but constructed for all counties. The 1860 border between free and slave states is drawn for reference. For Panel A, we construct an index calibrated to the county's slave-population density. For Panel B, the index is calibrated to the slave share of the population in each county. Data sources and variable definitions are described in the text.

Figure 4: Ecological Index of Rural Population Density vs the Free-Slave Border



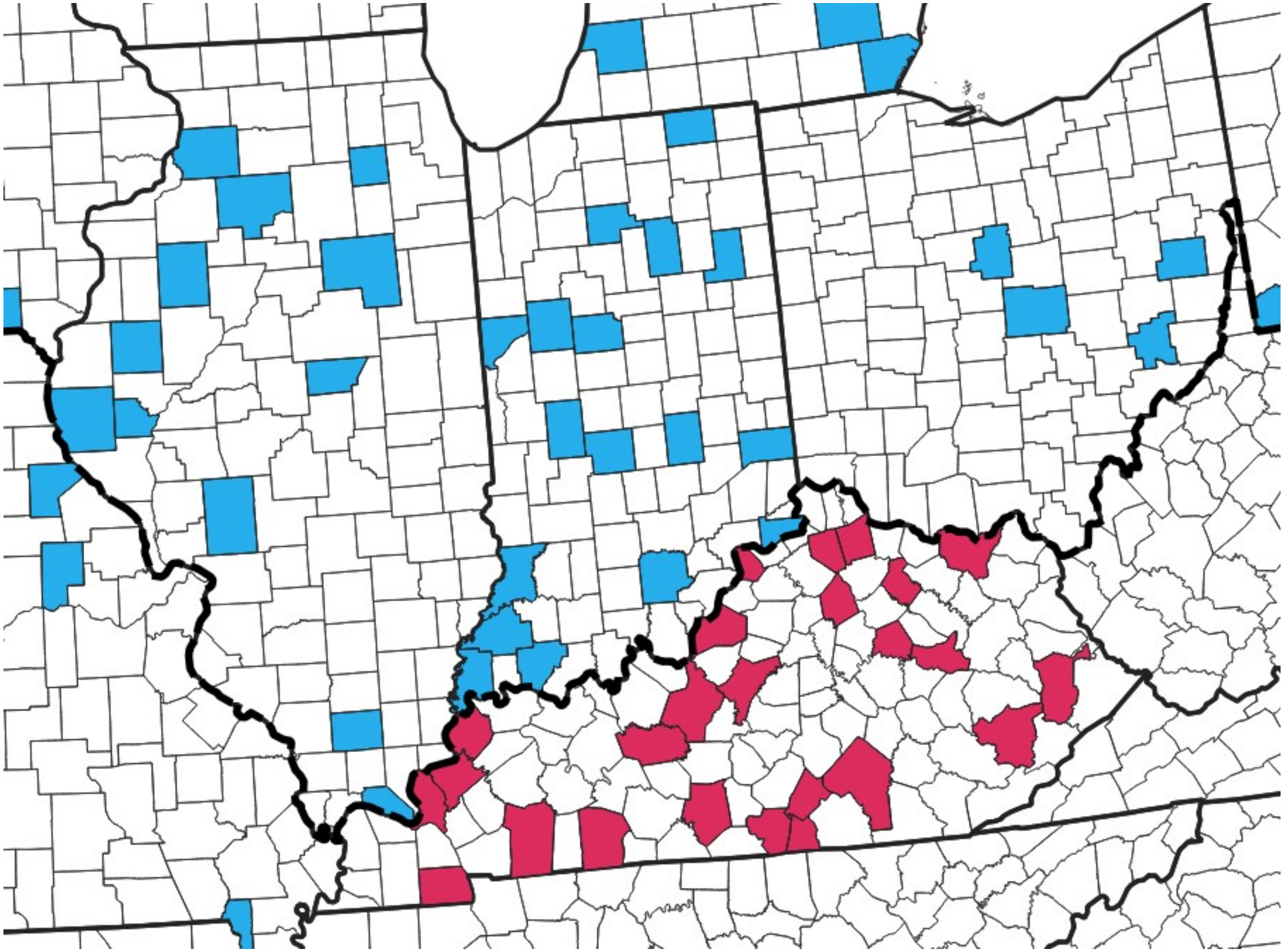
Notes: This figure displays ecological indices of rural population density, calibrated on Free Soil, as compared to the county's distance from the 1860 free-slave border. Counties on free soil are assigned negative distances. Counties where slavery was legal (thus with a positive distance in the graph) are predictions out of the calibration sample. The line drawn (for positive distance) represents an area-weighted quadratic best fit of the index to distance in the slavery-legal subsample. The default index uses the geological variables and a quadratic in weather as predictors. Except for Panel C, we use Ridge to estimate the index, with the smoothing parameter calibrated with cross validation on folds by 10 groupings of distance from the border. Panel B uses instead an index calibrated to the same variables plus interactions of all of the geological variables with the weather quadratic. Panel C uses an index in which OLS is used to construct the index instead of Ridge. Panel D is the same as Panel A, except that the variables south of the free-slave border are denoted with gray dots instead if they are within the support of the distribution of all variables in the Free-Soil counties. Data sources and variable definitions are described in the text.

Figure 5: Regression Coefficients for Hedonic Model, Farm Value per County Area



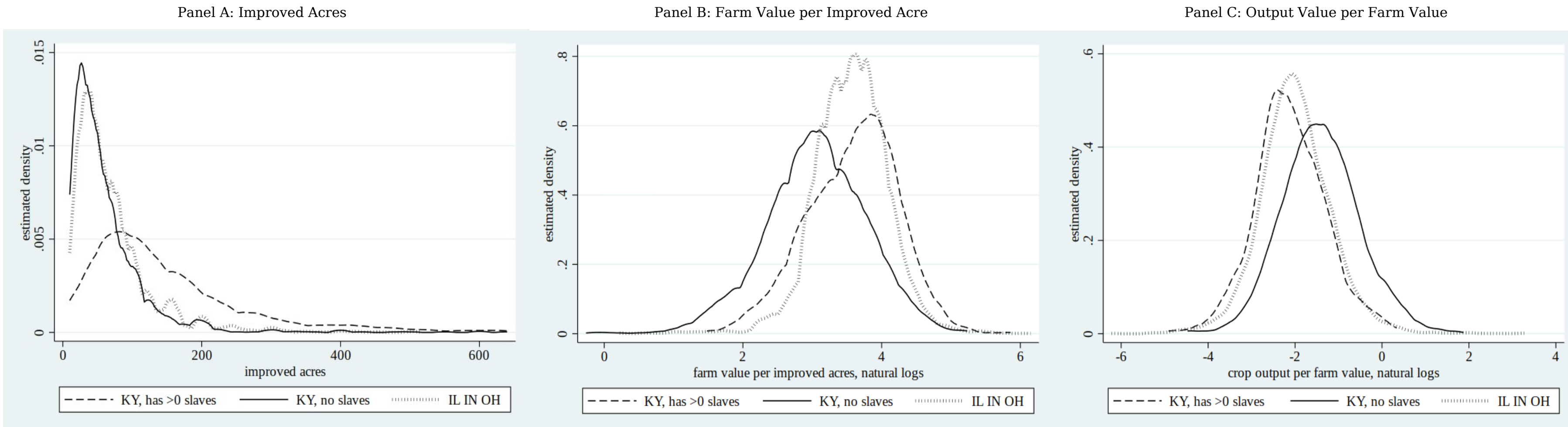
Notes: this reproduces coefficient estimates from Table 1, columns (2) and (7).

Figure 6: Coverage of Kentucky Farm Sample and Bateman-Foust Sample in IL/IN/OH



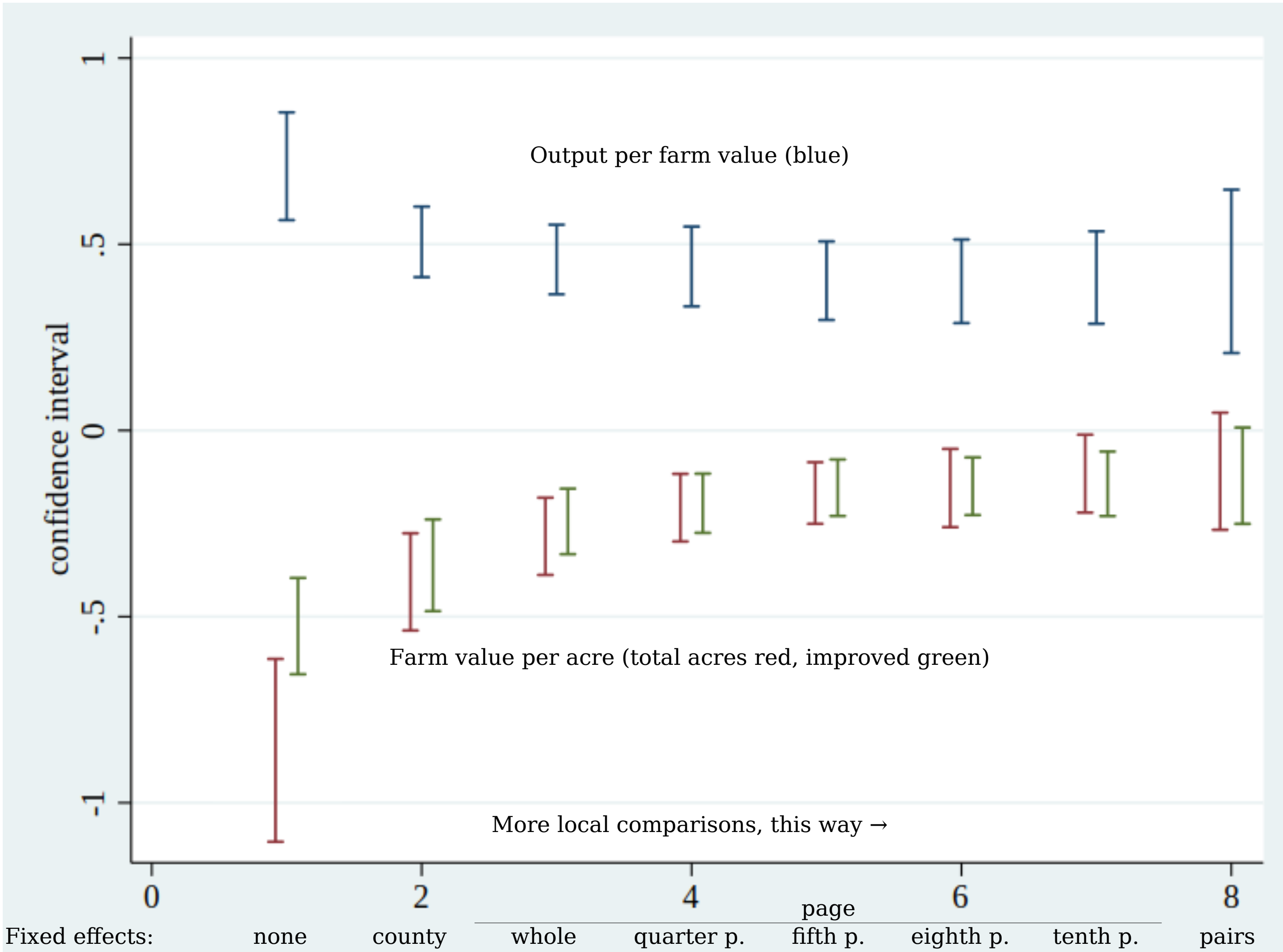
Notes: This is a map of 1860 counties using boundaries from NHGIS. Shading of a county denotes inclusion in one of two samples from the 1860 agricultural census. Counties in Kentucky are shaded if they were included in our random sample of 30 pages. Counties outside Kentucky are shaded if they are in the Bateman-Foust random sample of 1860 townships. (For the analysis of farms on free soil, we use the subsample of Bateman and Foust from Illinois, Indiana, and Ohio.) Data sources and variable definitions are described in the text.

Figure 7: Distributions of Various Outcomes, Farms using Slave Labor versus Free Labor Only



Notes: These graphs are estimated probability distribution functions of the indicated variables for the indicated subsamples. For free farms on Free Soil, we use farms in the Bateman-Foust sample from Illinois, Indiana, and Ohio. For the other two subsets, we use our own sample of 30 pages from Kentucky, split into farms with and without slaves. Data sources and variable definitions are described in the text.

Figure 8: Confidence Intervals from Regressions of Select Outcomes on Farm using Slave Labor, KY Sample



Notes: This graph displays 95% confidence intervals for the estimated difference, for the indicated variables, between Kentucky farms with and without slaves. Outcomes are in natural logs. Each regression includes an indicator variable for using slave labor and fixed effects for proximity. These fixed effects are progressively more local while moving right on the graph. The first (leftmost) set of estimates is the comparison of means within the state, while the second set uses a county fixed effect. The remaining estimates use the page itself to construct a fixed effect, moving from being on the same page as a fixed effect to being on the same 20th of a page (and therefore on adjacent lines). Data sources and variable definitions are described in the text.

Table 1: Regional differences in the effects of leave-out-own-county ecological indices

	Free-soil states					Slavery-legal states						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre	Slave population fraction (levels)	Slave population fraction (log odds)
Control variables:												
Panel A: Index from Own Region												
Index calibrated to free states	0.557	0.810	0.292	0.518	0.660							
	(0.0652)	(0.101)	(0.0687)	(0.0822)	(0.0904)							
Index calibrated to slave states						0.613	0.886	0.447	0.439	0.849	0.127	1.072
						(0.0734)	(0.171)	(0.0883)	(0.125)	(0.134)	(0.015)	(0.159)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel B: Index from Other Region												
Index calibrated to free states						0.181	0.162	0.093	0.069	0.215	0.032	0.253
						(0.0402)	(0.0837)	(0.0621)	(0.0255)	(0.0490)	(0.019)	(0.126)
Index calibrated to slave states	0.108	0.038	0.018	0.020	-0.094							
	(0.137)	(0.232)	(0.128)	(0.126)	(0.155)							
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel C: Index from Both Regions												
Index calibrated to free states	0.554	0.816	0.294	0.523	0.676	0.063	-0.030	-0.002	-0.029	0.042	0.006	0.036
	(0.0610)	(0.0935)	(0.0658)	(0.0774)	(0.0884)	(0.0334)	(0.0691)	(0.0523)	(0.0280)	(0.0392)	(0.020)	(0.130)
Index calibrated to slave states	0.034	-0.072	-0.021	-0.050	-0.185	0.565	0.910	0.448	0.461	0.817	0.122	1.045
	(0.0928)	(0.164)	(0.104)	(0.0855)	(0.107)	(0.0952)	(0.183)	(0.0925)	(0.132)	(0.148)	(0.027)	(0.244)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel D: Omit Spatial Controls												
Index calibrated to free states	0.958	1.219	0.440	0.780	1.076	0.088	0.003	-0.058	0.061	0.111	0.046	0.340
	(0.163)	(0.161)	(0.0299)	(0.156)	(0.188)	(0.0268)	(0.0252)	(0.0183)	(0.0296)	(0.0372)	(0.016)	(0.099)
Index calibrated to slave states	-0.067	-0.164	-0.184	0.020	-0.122	0.659	1.026	0.486	0.540	0.910	0.065	0.588
	(0.0986)	(0.159)	(0.0991)	(0.0969)	(0.119)	(0.122)	(0.192)	(0.0696)	(0.208)	(0.186)	(0.025)	(0.189)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel E: Index has Interactions with Temperature and Rainfall												
Index calibrated to free states	0.519	0.761	0.276	0.485	0.626	-0.021	-0.150	-0.077	-0.073	-0.073	-0.011	-0.076
	(0.0617)	(0.0934)	(0.0574)	(0.0728)	(0.0859)	(0.0204)	(0.0515)	(0.0373)	(0.0251)	(0.0288)	(0.017)	(0.109)
Index calibrated to slave states	0.132	-0.012	-0.068	0.056	-0.019	0.882	1.348	0.686	0.662	1.227	0.163	1.369
	(0.0846)	(0.108)	(0.0647)	(0.0859)	(0.110)	(0.0645)	(0.152)	(0.113)	(0.129)	(0.110)	(0.024)	(0.179)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel F: Leave Out Own State from Estimation of Indices												
Index calibrated to free states	0.320	0.491	0.216	0.274	0.339	0.104	0.023	0.041	-0.018	0.090	0.010	0.081
	(0.0549)	(0.0996)	(0.0663)	(0.0530)	(0.0915)	(0.0453)	(0.0967)	(0.0716)	(0.0367)	(0.0555)	(0.023)	(0.156)
Index calibrated to slave states	0.101	-0.106	-0.044	-0.062	-0.318	0.640	1.074	0.412	0.662	0.989	0.174	1.380
	(0.210)	(0.362)	(0.209)	(0.206)	(0.252)	(0.178)	(0.322)	(0.144)	(0.238)	(0.272)	(0.053)	(0.430)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel G: Sample Restricted to Counties Within 150 miles of Free-Slave Border												
Index calibrated to free states	0.361	0.562	0.306	0.256	0.397	0.205	0.226	0.178	0.047	0.253	0.021	0.129
	(0.0289)	(0.0696)	(0.0562)	(0.0311)	(0.0681)	(0.0890)	(0.123)	(0.117)	(0.0672)	(0.106)	(0.027)	(0.199)
Index calibrated to slave states	-0.159	-0.325	-0.172	-0.154	-0.220	0.686	1.019	0.552	0.467	0.939	0.101	1.159
	(0.0798)	(0.120)	(0.0686)	(0.0773)	(0.117)	(0.106)	(0.233)	(0.128)	(0.125)	(0.187)	(0.027)	(0.301)
	[409]	[411]	[411]	[411]	[411]	[404]	[405]	[405]	[405]	[405]	[698]	[696]
Panel H: Sample Expanded to All Counties												
Index calibrated to free states	0.563	1.004	0.248	0.755	0.961	0.133	0.008	0.056	-0.048	0.105	0.022	0.110
	(0.0601)	(0.0837)	(0.0616)	(0.0929)	(0.0988)	(0.0720)	(0.102)	(0.0631)	(0.0909)	(0.0966)	(0.017)	(0.099)
Index calibrated to slave states	-0.027	-0.252	0.104	-0.356	-0.493	0.702	1.054	0.039	1.016	0.991	0.055	0.459
	(0.132)	(0.0671)	(0.109)	(0.0845)	(0.103)	(0.116)	(0.0823)	(0.129)	(0.110)	(0.0659)	(0.026)	(0.162)
	[765]	[749]	[749]	[749]	[749]	[1100]	[1089]	[1089]	[1089]	[1089]	[698]	[696]

Notes: this table presents estimates of the relationship, in each region, between various outcomes indicated in the column headings and indices calibrated to each region under different specification assumptions. Standard errors, clustered by 10 bins of latitude, are in parentheses, and sample sizes are in square brackets. Each county's index is a prediction from all of the other counties. (That is, we omit the county from the sample when estimating its own index value.) Data sources and variable definitions are described in the text.

Table 2: Shares model for effects of ecological indices in slave states (300-mile buffer)

	(1)	(2)	(3)	(4)	(5)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre
Control variables:					
Panel A: OLS					
Index calibrated to free states * (1 – slave fraction of population)	0.160 (0.042)	-0.003 (0.073)	0.004 (0.047)	-0.008 (0.035)	0.120 (0.042)
Index calibrated to slave states * (slave fraction of population)	0.664 (0.085)	1.141 (0.176)	0.717 (0.126)	0.424 (0.086)	0.999 (0.129)
	[696]	[695]	[695]	[695]	[695]
Panel B: 2SLS, use regional indices as instruments					
Index calibrated to free states * (1 – slave fraction of population)	-0.027 (0.121)	-0.224 (0.132)	-0.110 (0.0834)	-0.114 (0.0734)	-0.122 (0.145)
Index calibrated to slave states * (slave fraction of population)	0.977 (0.151)	1.380 (0.287)	0.720 (0.175)	0.660 (0.165)	1.347 (0.249)
	[696]	[695]	[695]	[695]	[695]
Panel C: 2SLS, add indices for slave density and population fraction as instruments					
Index calibrated to free states * (1 – slave fraction of population)	0.047 (0.102)	-0.155 (0.0888)	-0.058 (0.0657)	-0.097 (0.0683)	-0.005 (0.0991)
Index calibrated to slave states * (slave fraction of population)	0.864 (0.126)	1.294 (0.224)	0.650 (0.140)	0.644 (0.145)	1.180 (0.174)
	[696]	[695]	[695]	[695]	[695]
Panel D: 2SLS, inflate slavery coefficient					
Index calibrated to free states * (1 – slave fraction of population)	-0.108 (0.253)	-0.368 (0.300)	-0.185 (0.151)	-0.182 (0.159)	-0.262 (0.324)
Index calibrated to slave states * (slave fraction of population)			[fixed at double value in Panel B.]		
	[696]	[695]	[695]	[695]	[695]
Panel E: 2SLS, indices include interaction of variables with climate polynomial					
Index calibrated to free states * (1 – slave fraction of population)	-0.080 (0.0899)	-0.281 (0.112)	-0.160 (0.0748)	-0.122 (0.0441)	-0.189 (0.112)
Index calibrated to slave states * (slave fraction of population)	1.191 (0.158)	1.632 (0.295)	0.861 (0.198)	0.771 (0.166)	1.580 (0.255)
	[696]	[695]	[695]	[695]	[695]
Panel F: 2SLS, expand to full sample of counties in slavery-legal region					
Index calibrated to free states * (1 – slave fraction of population)	0.329 (0.275)	-0.173 (0.138)	-0.078 (0.0743)	-0.095 (0.135)	-0.001 (0.134)
Index calibrated to slave states * (slave fraction of population)	1.109 (0.0815)	1.706 (0.227)	0.362 (0.142)	1.344 (0.289)	1.715 (0.239)
	[1100]	[1089]	[1089]	[1089]	[1089]

Notes: This table presents estimates of the relationship, in each region, between various outcomes indicated in the column headings and indices calibrated to each region under different specification assumptions. Standard errors, clustered by 10 bins of latitude, are in parentheses, and sample sizes are in square brackets. Each county's index is a prediction from all of the other counties. (That is, we omit the county from the sample when estimating its own index value.) Data sources and variable definitions are described in the text.

Table 3: Log Output per Farm Value in the Kentucky and Bateman-Foust Samples

	(1)	(2)	(3)
KY farms with no slaves	0.709 (0.042)	0.709 (0.072)	0.459 (0.047)
KY farms with slaves		[omitted category]	
Farms in IL/IN/OH	0.144 (0.037)	---	---
Cluster for microfilm roll & page	No	Yes	Yes
Fixed effect for microfilm roll & page	No	No	Yes
Sample	KY & B/F	KY only	KY only
Number of observations	[6141]	[1931]	[1931]
Adjusted R^2	{0.08}	{0.12}	{0.32}

Notes: authors' calculations using random sample of pages from 1860 Agricultural Schedule in Kentucky and extract for Illinois, Indiana, and Ohio from Bateman-Foust sample of farms. Free farms, having no slaves, made up 74.6 percent of the total sample from Kentucky. Output is constructed from farm-level quantities and average prices in Kentucky in 1859.

Table 4: Comparison of Farm Value and Output Per Farm Value in Other Samples

	Parker and Gallman (cotton counties)		Irwin (Piedmont Virginia)	
	(1)	(2)	(3)	(4)
Outcomes (in natural logarithms):	Farm value per acre	Output per farm value	Farm value per acre	Output per farm value
Farms with no slaves	-0.146 (0.023)	0.077 (0.035)	-0.351 (0.061)	0.284 (0.127)
Farms with slaves		[omitted category]		
Cluster for microfilm roll & page	Yes	Yes	Yes	Yes
Fixed effect for microfilm roll & page	Yes	Yes	Yes	Yes
Percent of farms with no slaves	50.5	50.5	25.4	25.4
Number of observations	5053	4992	542	537
Adjusted R^2	0.645	0.432	0.308	0.369

Notes: authors' calculations using Parker and Gallman's (1991) sample of farms in the Cotton South and Irwin's (1988) sample of farms in the select counties in the Virginia Piedmont. Both studies drew five farms from randomly sampled pages within the indicate regions. Total output value is constructed with farm-level quantities and state-level prices.

Appendix

Appendix Tables 1 and 2 replicate the results for Table 1 and 2, respectively, using suitability indices estimated by OLS rather than Ridge regression. The results are robust to this change.

We now relate the findings of this paper to the framework of our border paper (Bleakley and Rhode 2022). There, we compared the economic effects of the institution of slavery across locations which, according to antebellum observers, had fundamentally similar environments. The design had the beauty of a controlled experiment. Current-day observers have asked us whether there were subtle environment differences within the border region across locations regarding their suitability to slave or free settlement that would affect our results; they have also asked whether the results from the border sample extend beyond the region, for example, further South.[20]

We can use the suitability indices developed above within our border-design regression framework from our earlier paper. We first compare the estimated coefficient for the slavery-legal variable in samples split at median suitability in the 300-mile buffer sample. That is, we assign those counties with low predicted values for, say, fraction slave to the "Below median" or "less suitable" group and those with high predicted values to the "Above median" or "more suitable" group. We then run our standard regressions within each sample and compare the slavery-legal coefficients.

Table Appendix 3 reports results akin to our previous baseline (Panel A) and then new findings for sample splits based on the fraction of the population enslaved (Panel B), the density of the enslaved population (Panel C), rural population density calibrated to the slave region (Panel D), and rural population density calibrated to the free-soil region (Panel E). We examine the slavery-legal effects on the non-white population density, the white population density, the rural population density, total farm acres per county area, improved farm acres per total farm acres, farm value per county acre, and farm value per total farm acres. We focus the discussion on rural population per county acre and farm value per county acre.

[20] The effects of the peculiar institution depended on how suitable the land is for slave-labor versus free-labor uses. While it would be tempting to use the measures of crop suitability (from the FAO/GAEZ) commonly used in the literature, we believe – for reasons documented in the elsewhere—that approach deeply problematic. FAO/GAEZ places the zone highly suitable for cotton is the wrong place.

We do find some heterogeneity in slavery's effects depending on environmental characteristics. But the signs in the various subsamples and specifications always match those in the baseline specification. The slavery-legal effects differ in magnitude, but never disappear.

The results show the slavery-legal effect on the non-white population, column (1), is positive in every subsample while that on the white population, column (2), is always negative. These findings are in line with the baseline results. The effects for non-white density are stronger in the places in the above median predicted fraction enslaved and density enslaved (Panel B and C). This is perhaps as expected. What may be surprising is the effects of whites are weaker in such places.

The slavery-legal effect on rural population density, column (3), is always negative. But the gap is smaller in places with above median predicted fraction enslaved and density enslaved. White density in the slave region was depressed everywhere, but especially depressed in areas not suited to slavery. Panel E, based on the predicted rural population density as calibrated in the free-soil sample, provides additional illumination. It shows negative effects of the slavery-legal variable on rural and white population densities, in line with the baseline results. But here the gap is larger for the "above median" category, as measured by suitability for free-soil settlement. The institutions clearly have differential effects of the rural population densities predicted given pre-determined environmental conditions.

In column (6), on farm values per county acre, the slavery-legal effect is negative in every subsample, as it was in the baseline. Again, for Panels B-D, the gap is smaller (and typically statistically insignificant) in places in the "above median" categories. Again, for Panel E, with predictions are based on the free-soil region, the gap is larger in places in the "above median" settlement category.

In summary, the results for indices measuring suitability for slavery imply that the costs of the peculiar institution were greatest where slavery was less suitable. The results for predicted rural population density are more nuanced. By the calibration fitted to the slavery-legal region, the damage of having slavery is similar in above and below median groups. But, by the calibration fitted to the free regions, the damage is worse in areas more suited for free settlement.

Where does the larger gap come from? Is it due to conditions on the free side, or on the slave side? Examining these issues using an interaction framework proves clarifying. We add to the baseline model, the index, φ_r, and its interaction with being in a slave state. Appendix Table 2 reports, in an analogous format, the results of the regression:

$$\text{(A1) } Y=\alpha \text{ Slavery\_Legal}+\beta \text{ Index}+\chi \text{Slavery\_Legal}*\varphi_r \quad + \text{ Spatial Controls}$$

where S is the is the dummy for slavery legal and φ is the index of choice derived from those above. The index, φ_r, is continuous and has been rescaled so that the full range of the variable is unity. The interaction, Slavery_Legal*φ_r, is constructed to evaluate each main effect at the mean of the other variable.

The suitability indices themselves perform as expected; they are predictive of greater density, improvement, and farm values per county area. For the indices calibrated in the slavery region, greater suitability attenuates the effect of slavery. The main effect of slavery remains negative, but this effect is weaker in places where the ecological variables would predict greater settlement. For the index calibrated on free soil, however, greater suitability predicts a stronger adverse effect of slavery. Here the interaction effect switches sign. This indicates that the effect of the peculiar institution is even more negative in areas predicted to have greater rural population density. (Per construction of the variables, the estimated main effect of slavery is similar to the baseline results because it is evaluated at the mean of the index.) This makes sense if the spatial pattern of within-region settlement is a function of institutions.

In each region, the given index picks up both the effect of the ecological variables and how they are filtered through institutions. A location that scores highly on one index, but not the other, is better suited to one institution versus the other. In general, the slavery effect is diminished with an increased in an index calibrated on the slavery-legal region; the effect is intensified with an increased in an index calibrated in the free-soil region. In each case, the weights are optimized to pick up how the institutions map endowments to settlement activity.

As a summary, the institutions value environmental endowments differently. In addition, the free-soil institutions would support higher population densities and farm values thorough much of the border South region. The effects of the slave-legal variable on improvement and farm values are a. more adverse in places with below median suitability for slavery; b. below median rural population density as calibrated to the slavery-legal region; and c. above median rural population density as calibrated to the free-soil region.

Appendix Table 1: Results for various sample splits based on predicted values from ecological models

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: Baseline							
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]
Panel B: Predicted fraction enslaved							
Below median	0.332	-1.352	-1.285	-0.346	-0.863	-1.572	-1.226
	(0.524)	(0.335)	(0.320)	(0.326)	(0.222)	(0.458)	(0.232)
	[652]	[730]	[727]	[727]	[727]	[727]	[727]
Above median	2.274	-0.364	-0.147	0.180	-0.077	-0.050	-0.230
	(0.530)	(0.194)	(0.151)	(0.117)	(0.112)	(0.340)	(0.262)
	[628]	[632]	[630]	[629]	[629]	[629]	[629]
Panel C: Predicted density of enslaved population							
Below median	1.444	-0.897	-0.788	-0.112	-0.618	-0.947	-0.834
	(0.629)	(0.380)	(0.377)	(0.361)	(0.209)	(0.457)	(0.204)
	[612]	[678]	[675]	[675]	[675]	[675]	[675]
Above median	2.173	-0.346	-0.248	0.057	-0.251	-0.316	-0.373
	(0.486)	(0.183)	(0.166)	(0.116)	(0.114)	(0.273)	(0.204)
	[668]	[684]	[682]	[681]	[681]	[681]	[681]
Panel D: Predicted density of rural population, calibration from slavery-legal region							
Below median	0.272	-1.586	-1.550	-0.588	-1.005	-2.043	-1.455
	(0.454)	(0.490)	(0.476)	(0.491)	(0.231)	(0.630)	(0.250)
	[611]	[678]	[676]	[674]	[674]	[674]	[674]
Above median	1.897	-0.336	-0.199	0.101	-0.241	-0.155	-0.256
	(0.516)	(0.207)	(0.174)	(0.104)	(0.131)	(0.253)	(0.194)
	[669]	[684]	[681]	[682]	[682]	[682]	[682]
Panel E: Predicted density of rural population, calibration from free-soil region							
Below median	2.690	-0.402	-0.327	-0.013	-0.248	-0.254	-0.241
	(0.433)	(0.204)	(0.215)	(0.217)	(0.147)	(0.290)	(0.191)
	[599]	[678]	[677]	[673]	[673]	[673]	[673]
Above median	1.285	-0.755	-0.538	0.039	-0.456	-0.680	-0.719
	(0.585)	(0.117)	(0.128)	(0.0979)	(0.169)	(0.262)	(0.225)
	[681]	[684]	[680]	[683]	[683]	[683]	[683]

Notes: this table presents estimates of the effect of being in the slavery-legal region. The specification uses the 1860 free-slave border to identify this effect on a sample of 1860 counties within 300 miles of the border. The regression also includes spatial controls: third-order polynomials in longitude and distance to the border. Panel A has estimates for the whole sample, while the remaining Panels split the sample by median of the indicated indices.

Appendix Table 2: Interaction of slavery with ecological indices

	(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: Baseline							
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]
Panel B: Interacted with predicted fraction enslaved							
Slavery region	1.887	-0.810	-0.545	-0.036	-0.275	-0.544	-0.508
	(0.437)	(0.159)	(0.160)	(0.191)	(0.111)	(0.274)	(0.180)
Predicted index	6.440	-0.078	0.621	0.655	-1.453	1.067	0.413
	(3.210)	(1.298)	(1.228)	(1.491)	(0.822)	(2.083)	(1.411)
Interaction of the two	-2.882	-4.594	-1.225	-0.620	4.205	0.522	1.142
	(7.919)	(3.445)	(3.057)	(2.985)	(1.745)	(5.321)	(3.614)
	[1275]	[1357]	[1352]	[1351]	[1351]	[1351]	[1351]
Panel C: Interacted with predicted density of enslaved population							
Slavery region	2.031	-0.589	-0.440	0.040	-0.384	-0.468	-0.509
	(0.399)	(0.157)	(0.145)	(0.145)	(0.129)	(0.232)	(0.164)
Predicted index	0.476	0.084	0.173	0.147	0.077	0.281	0.134
	(0.124)	(0.071)	(0.057)	(0.071)	(0.039)	(0.096)	(0.055)
Interaction of the two	0.698	-0.301	-0.017	-0.067	0.173	0.035	0.101
	(0.218)	(0.252)	(0.207)	(0.180)	(0.082)	(0.285)	(0.118)
	[1275]	[1357]	[1352]	[1351]	[1351]	[1351]	[1351]
Panel D: Interacted with predicted density of rural population, calibrated in slavery region							
Slavery region	1.285	-0.681	-0.661	-0.137	-0.580	-0.842	-0.704
	(0.409)	(0.180)	(0.158)	(0.110)	(0.144)	(0.273)	(0.204)
Predicted index	0.688	0.127	0.249	0.187	0.135	0.308	0.121
	(0.112)	(0.063)	(0.044)	(0.073)	(0.053)	(0.080)	(0.065)
Interaction of the two	1.400	0.044	0.311	0.237	0.446	0.608	0.370
	(0.286)	(0.227)	(0.198)	(0.162)	(0.108)	(0.273)	(0.173)
	[1275]	[1357]	[1352]	[1351]	[1351]	[1351]	[1351]
Panel E: Interacted with predicted density of rural population, calibrated in free-soil region							
Slavery region	1.955	-0.633	-0.479	-0.008	-0.364	-0.564	-0.556
	(0.430)	(0.211)	(0.212)	(0.206)	(0.140)	(0.302)	(0.165)
Predicted index	0.487	0.477	0.448	0.338	0.182	0.558	0.220
	(0.123)	(0.066)	(0.064)	(0.060)	(0.029)	(0.086)	(0.054)
Interaction of the two	-0.464	-0.738	-0.587	-0.469	-0.113	-0.829	-0.360
	(0.151)	(0.177)	(0.171)	(0.153)	(0.056)	(0.186)	(0.045)
	[1275]	[1357]	[1352]	[1351]	[1351]	[1351]	[1351]

Notes: this table presents estimates of the effect of being in the slavery-legal region. The specification uses the 1860 free-slave border to identify this effect on a sample of 1860 counties within 300 miles of the border. The regression also includes spatial controls: third-order polynomials in longitude and distance to the border. Panel A has estimates for the main effect, while the remaining Panels have estimates of the main effect of slavery, of the indicated index, and the interaction of the two. The variables are demeaned before interaction to facilitate interpretation of the main effects.

Appendix Table 3: Replicate Table 1 (regional differences in index effects) with calibration of index by OLS instead of Ridge

	Free-soil states					Slavery-legal states						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre	Slave population fraction (levels)	Slave population fraction (log odds)
Control variables:												
Panel A: Index from Own Region												
Index calibrated to free states	0.524 (0.120)	0.703 (0.122)	0.191 (0.0515)	0.512 (0.125)	0.648 (0.116)							
Index calibrated to slave states						0.508 (0.0592)	0.757 (0.132)	0.388 (0.0664)	0.369 (0.105)	0.714 (0.105)	0.109 (0.011)	0.947 (0.125)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel B: Index from Other Region												
Index calibrated to free states						0.108 (0.0318)	0.078 (0.0726)	0.030 (0.0519)	0.048 (0.0248)	0.139 (0.0458)	0.007 (0.014)	0.059 (0.104)
Index calibrated to slave states	0.075 (0.0761)	0.047 (0.129)	0.047 (0.0703)	0.000 (0.0694)	-0.074 (0.0820)							
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel C: Index from Both Regions												
Index calibrated to free states	0.521 (0.122)	0.704 (0.123)	0.188 (0.0562)	0.516 (0.125)	0.660 (0.117)	0.049 (0.0202)	-0.020 (0.0489)	-0.021 (0.0378)	0.001 (0.0163)	0.053 (0.0280)	-0.007 (0.011)	-0.064 (0.080)
Index calibrated to slave states	0.032 (0.0593)	-0.011 (0.0990)	0.031 (0.0655)	-0.042 (0.0427)	-0.128 (0.0504)	0.474 (0.0654)	0.771 (0.137)	0.402 (0.0688)	0.368 (0.106)	0.677 (0.107)	0.114 (0.014)	0.992 (0.155)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel D: Omit Spatial Controls												
Index calibrated to free states	0.876 (0.114)	1.105 (0.106)	0.380 (0.0167)	0.725 (0.114)	0.999 (0.126)	0.088 (0.0229)	0.035 (0.0319)	-0.027 (0.0267)	0.062 (0.0237)	0.116 (0.0286)	-0.009 (0.018)	-0.089 (0.130)
Index calibrated to slave states	0.017 (0.0418)	0.002 (0.0733)	-0.063 (0.0598)	0.065 (0.0334)	0.016 (0.0410)	0.521 (0.0897)	0.832 (0.163)	0.401 (0.0606)	0.431 (0.166)	0.723 (0.139)	0.112 (0.020)	0.972 (0.160)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel E: Index has Interactions with Temperature and Rainfall												
Index calibrated to free states	0.025 (0.0216)	0.027 (0.0260)	0.004 (0.00572)	0.023 (0.0207)	0.028 (0.0244)	0.000 (8.15e-05)	0.000 (7.17e-05)	0.000 (2.74e-05)	0.000 (5.80e-05)	0.000 (7.72e-05)	0.000 (2.23e-05)	0.000 (1.22e-05)
Index calibrated to slave states	0.006 (0.00766)	0.007 (0.0101)	0.000 (0.00265)	0.007 (0.00858)	0.010 (0.0115)	0.442 (0.182)	0.635 (0.272)	0.343 (0.157)	0.292 (0.129)	0.595 (0.244)	0.063 (0.030)	0.543 (0.262)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel F: Leave Out Own State from Estimation of Indices												
Index calibrated to free states	0.108 (0.0281)	0.173 (0.0422)	0.063 (0.0367)	0.110 (0.0426)	0.152 (0.0550)	0.065 (0.0221)	0.002 (0.0563)	-0.004 (0.0457)	0.006 (0.0158)	0.072 (0.0291)	-0.006 (0.012)	-0.050 (0.087)
Index calibrated to slave states	0.042 (0.0598)	-0.006 (0.103)	0.028 (0.0691)	-0.033 (0.0510)	-0.120 (0.0572)	0.265 (0.0627)	0.455 (0.120)	0.203 (0.0528)	0.251 (0.0935)	0.399 (0.0949)	0.079 (0.014)	0.666 (0.139)
	[656]	[656]	[656]	[656]	[656]	[696]	[695]	[695]	[695]	[695]	[698]	[696]
Panel G: Sample Restricted to Counties Within 150 miles of Free-Slave Border												
Index calibrated to free states	0.352 (0.0484)	0.511 (0.0635)	0.226 (0.0535)	0.285 (0.0518)	0.409 (0.0597)	0.063 (0.0595)	0.086 (0.0855)	0.046 (0.0640)	0.041 (0.0436)	0.134 (0.0834)	-0.004 (0.011)	-0.032 (0.096)
Index calibrated to slave states	-0.152 (0.0648)	-0.247 (0.0818)	-0.099 (0.0512)	-0.148 (0.0555)	-0.199 (0.0825)	0.589 (0.0569)	0.911 (0.147)	0.515 (0.0770)	0.396 (0.0947)	0.823 (0.109)	0.093 (0.015)	1.081 (0.196)
	[409]	[411]	[411]	[411]	[411]	[404]	[405]	[405]	[405]	[405]	[406]	[404]
Panel H: Sample Expanded to All Counties												
Index calibrated to free states	0.377 (0.0435)	0.669 (0.110)	0.155 (0.0514)	0.514 (0.0747)	0.677 (0.0879)	0.062 (0.0250)	0.018 (0.0478)	0.002 (0.0434)	0.017 (0.0259)	0.088 (0.0228)	-0.010 (0.009)	-0.098 (0.067)
Index calibrated to slave states	-0.031 (0.0602)	-0.117 (0.0505)	0.109 (0.0701)	-0.226 (0.0588)	-0.311 (0.0629)	0.625 (0.100)	0.842 (0.0622)	0.030 (0.112)	0.812 (0.0888)	0.807 (0.0435)	0.063 (0.022)	0.516 (0.125)
	[765]	[749]	[749]	[749]	[749]	[1100]	[1089]	[1089]	[1089]	[1089]	[1103]	[1093]

Notes: See notes from Table 1. The indices here are calibrated with OLS rather than Ridge.

Appendix Table 4: Replicate Table 2 (shares model) with ecological index calibrated with OLS

	(1)	(2)	(3)	(4)	(5)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre
Control variables:					
Panel A: OLS					
Index calibrated to free states * (1 – slave fraction of population)	0.102	0.042	0.007	0.035	0.121
	(0.0332)	(0.0627)	(0.0434)	(0.0255)	(0.0457)
Index calibrated to slave states * (slave fraction of population)	0.482	0.975	0.598	0.377	0.803
	(0.0829)	(0.149)	(0.100)	(0.0900)	(0.113)
	[696]	[695]	[695]	[695]	[695]
Panel B: 2SLS, use regional indices as instruments					
Index calibrated to free states * (1 – slave fraction of population)	0.064	-0.043	-0.042	-0.002	0.057
	(0.0573)	(0.0552)	(0.0363)	(0.0336)	(0.0635)
Index calibrated to slave states * (slave fraction of population)	0.756	1.172	0.641	0.532	1.081
	(0.127)	(0.234)	(0.127)	(0.155)	(0.200)
	[696]	[695]	[695]	[695]	[695]
Panel C: 2SLS, add indices for slave density and population fraction as instruments					
Index calibrated to free states * (1 – slave fraction of population)	0.089	-0.022	-0.035	0.013	0.083
	(0.0492)	(0.0579)	(0.0391)	(0.0308)	(0.0584)
Index calibrated to slave states * (slave fraction of population)	0.664	1.125	0.631	0.494	1.002
	(0.101)	(0.205)	(0.113)	(0.139)	(0.162)
	[696]	[695]	[695]	[695]	[695]
Panel D: 2SLS, inflate slavery coefficient					
Index calibrated to free states * (1 – slave fraction of population)	0.057	-0.071	-0.057	-0.014	0.031
	(0.117)	(0.131)	(0.064)	(0.073)	(0.147)
Index calibrated to slave states * (slave fraction of population)	[fixed at double value in Panel B.]				
	[696]	[695]	[695]	[695]	[695]
Panel E: 2SLS, indices calibrated with interaction of variables with climate polynomial					
Index calibrated to free states * (1 – slave fraction of population)	-0.001	-0.001	0.000	0.000	-0.001
	(0.000630)	(0.000959)	(0.000598)	(0.000365)	(0.000919)
Index calibrated to slave states * (slave fraction of population)	1.202	1.729	1.003	0.726	1.607
	(0.124)	(0.230)	(0.148)	(0.160)	(0.208)
	[696]	[695]	[695]	[695]	[695]
Panel F: 2SLS, expand to full sample of counties in slavery-legal region					
Index calibrated to free states * (1 – slave fraction of population)	0.060	0.151	-0.080	0.231	0.278
	(0.144)	(0.0907)	(0.0644)	(0.121)	(0.0819)
Index calibrated to slave states * (slave fraction of population)	0.787	1.246	0.511	0.736	1.168
	(0.0862)	(0.217)	(0.0954)	(0.254)	(0.226)
	[1100]	[1089]	[1089]	[1089]	[1089]

Notes: See notes from Table 2. The indices here are calibrated with OLS rather than Ridge.

Appendix Table 5: Replicate Table 2 (shares model) with controls for PLSS coverage

	(1)	(2)	(3)	(4)	(5)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre
Control variables:					
Panel A: OLS					
Index calibrated to free states * (1 – slave fraction of population)	0.156	0.035	0.014	0.022	0.161
	(0.038)	(0.072)	(0.062)	(0.027)	(0.042)
Index calibrated to slave states * (slave fraction of population)	0.660	1.219	0.773	0.446	1.084
	(0.081)	(0.130)	(0.114)	(0.078)	(0.112)
	[696]	[695]	[695]	[695]	[695]
Panel B: 2SLS, use regional indices as instruments					
Index calibrated to free states * (1 – slave fraction of population)	0.078	-0.161	-0.165	0.004	0.027
	(0.154)	(0.135)	(0.076)	(0.105)	(0.165)
Index calibrated to slave states * (slave fraction of population)	1.207	1.633	0.620	1.013	1.725
	(0.279)	(0.431)	(0.245)	(0.225)	(0.396)
	[696]	[695]	[695]	[695]	[695]
Panel C: 2SLS, add indices for slave density and population fraction as instruments					
Index calibrated to free states * (1 – slave fraction of population)	0.107	-0.111	-0.138	0.027	0.084
	(0.129)	(0.108)	(0.075)	(0.088)	(0.132)
Index calibrated to slave states * (slave fraction of population)	1.041	1.455	0.546	0.909	1.469
	(0.173)	(0.336)	(0.222)	(0.174)	(0.277)
	[696]	[695]	[695]	[695]	[695]
Panel D: 2SLS, inflate slavery coefficient					
Index calibrated to free states * (1 – slave fraction of population)	0.295	0.115	-0.060	0.175	0.319
	(0.230)	(0.241)	(0.089)	(0.178)	(0.275)
Index calibrated to slave states * (slave fraction of population)	[fixed at double value in Panel B.]				
	[696]	[695]	[695]	[695]	[695]
Panel E: 2SLS, indices calibrated with interaction of variables with climate polynomial					
Index calibrated to free states * (1 – slave fraction of population)	0.120	-0.105	-0.124	0.020	0.053
	(0.152)	(0.113)	(0.047)	(0.089)	(0.151)
Index calibrated to slave states * (slave fraction of population)	1.618	2.052	0.935	1.116	2.121
	(0.383)	(0.488)	(0.273)	(0.291)	(0.501)
	[696]	[695]	[695]	[695]	[695]
Panel F: 2SLS, expand to full sample of counties in slavery-legal region					
Index calibrated to free states * (1 – slave fraction of population)	0.199	-0.106	-0.133	0.028	0.148
	(0.121)	(0.143)	(0.137)	(0.197)	(0.159)
Index calibrated to slave states * (slave fraction of population)	0.877	1.482	0.483	0.999	1.540
	(0.119)	(0.167)	(0.128)	(0.088)	(0.143)
	[1100]	[1089]	[1089]	[1089]	[1089]

Notes: See notes from Table 2. This table reports results when controlling for the fraction of the counties land in the Public Land Survey System (PLSS) and its interaction with the rural-density indices. The variables are de-meaned before constructing the interaction.

Appendix Table 6: Replicate Table 2 (shares model) with controls for Glacier coverage

	(1)	(2)	(3)	(4)	(5)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre
Control variables:					
Panel A: OLS					
Index calibrated to free states * (1 – slave fraction of population)	0.057	0.034	0.078	-0.044	0.092
	(0.041)	(0.083)	(0.064)	(0.048)	(0.047)
Index calibrated to slave states * (slave fraction of population)	0.343	1.044	0.830	0.214	0.758
	(0.106)	(0.149)	(0.119)	(0.075)	(0.123)
	[696]	[695]	[695]	[695]	[695]
Panel B: 2SLS, use regional indices as instruments					
Index calibrated to free states * (1 – slave fraction of population)	-0.023	-0.074	-0.080	0.006	0.000
	(0.090)	(0.087)	(0.070)	(0.058)	(0.110)
Index calibrated to slave states * (slave fraction of population)	0.166	0.569	0.542	0.026	0.570
	(0.320)	(0.470)	(0.283)	(0.202)	(0.421)
	[696]	[695]	[695]	[695]	[695]
Panel C: 2SLS, add indices for slave density and population fraction as instruments					
Index calibrated to free states * (1 – slave fraction of population)	-0.002	-0.064	-0.049	-0.016	0.052
	(0.091)	(0.079)	(0.055)	(0.062)	(0.087)
Index calibrated to slave states * (slave fraction of population)	0.213	0.787	0.466	0.321	0.442
	(0.191)	(0.310)	(0.207)	(0.149)	(0.265)
	[696]	[695]	[695]	[695]	[695]
Panel D: 2SLS, inflate slavery coefficient					
Index calibrated to free states * (1 – slave fraction of population)	-0.019	-0.070	-0.076	0.006	0.004
	(0.099)	(0.115)	(0.107)	(0.059)	(0.146)
Index calibrated to slave states * (slave fraction of population)			[fixed at double value in Panel B.]		
	[696]	[695]	[695]	[695]	[695]
Panel E: 2SLS, indices calibrated with interaction of variables with climate polynomial					
Index calibrated to free states * (1 – slave fraction of population)	-0.007	-0.088	-0.078	-0.010	-0.041
	(0.149)	(0.152)	(0.087)	(0.071)	(0.178)
Index calibrated to slave states * (slave fraction of population)	1.395	2.007	1.235	0.772	1.829
	(0.481)	(0.556)	(0.341)	(0.302)	(0.598)
	[696]	[695]	[695]	[695]	[695]
Panel F: 2SLS, expand to full sample of counties in slavery-legal region					
Index calibrated to free states * (1 – slave fraction of population)	0.096	0.038	-0.359	0.397	0.156
	(0.109)	(0.173)	(0.260)	(0.381)	(0.137)
Index calibrated to slave states * (slave fraction of population)	0.126	0.585	1.075	-0.490	0.472
	(0.172)	(0.487)	(0.270)	(0.723)	(0.569)
	[1100]	[1089]	[1089]	[1089]	[1089]

Notes: See notes from Table 2. This table reports results when controlling for the fraction of the county's land north of the terminal moraine and its interaction with the rural-density indices. The variables are de-meaned before constructing the interaction.

Appendix Table 7: Parts of Table 2 (shares model) with predicted slave share and OLS instead IV

	(1)	(2)	(3)	(4)	(5)
Outcomes (in natural logarithms):	Rural population per county acre	Farm value per county acre	Farm value per total farm acre	Total farm acres per county area	Improved acres per total farm acre
Control variables:					
Panel A: Baseline (same as Table 2, Panel A)					
Index calibrated to free states * (1 – slave fraction of population)	0.160 (0.0420)	-0.003 (0.0725)	0.004 (0.0473)	-0.008 (0.0348)	0.120 (0.0415)
Index calibrated to slave states * (slave fraction of population)	0.664 (0.0853)	1.141 (0.176)	0.717 (0.126)	0.424 (0.0864)	0.999 (0.129)
	[696]	[695]	[695]	[695]	[695]
Panel B: Use index for slave fraction pop					
Index calibrated to free states * (1 – index, slave fraction of pop.)	0.196 (0.0693)	0.089 (0.130)	0.098 (0.0944)	-0.010 (0.0544)	0.192 (0.0859)
Index calibrated to slave states * (index, slave fraction of pop.)	0.589 (0.166)	1.044 (0.279)	0.479 (0.183)	0.564 (0.172)	0.909 (0.221)
	[696]	[695]	[695]	[695]	[695]
Panel C: Use leave-out-own-state indices					
Index calibrated to free states * (1 – index, slave fraction of pop.)	0.219 (0.074)	0.140 (0.141)	0.153 (0.100)	-0.013 (0.064)	0.227 (0.095)
Index calibrated to slave states * (index, slave fraction of pop.)	1.007 (0.304)	1.696 (0.472)	0.688 (0.273)	1.008 (0.331)	1.561 (0.421)
	[696]	[695]	[695]	[695]	[695]
Panel D: Inflate slavery coefficient					
Index calibrated to free states * (1 – slave fraction of population)	-0.019 (0.099)	-0.070 (0.115)	-0.076 (0.107)	0.006 (0.059)	0.004 (0.146)
Index calibrated to slave states * (slave fraction of population)	[fixed at double value in Panel B.]				
	[696]	[695]	[695]	[695]	[695]
Panel E: Indices calibrated with interaction of variables with climate polynomial					
Index calibrated to free states * (1 – slave fraction of population)	0.125 (0.0507)	-0.017 (0.0885)	0.012 (0.0667)	-0.029 (0.0370)	0.086 (0.0547)
Index calibrated to slave states * (slave fraction of population)	0.531 (0.168)	1.154 (0.247)	0.547 (0.188)	0.607 (0.155)	0.923 (0.189)
	[696]	[695]	[695]	[695]	[695]
Panel F: Expand to full sample of counties in slavery-legal region					
Index calibrated to free states * (1 – slave fraction of population)	0.415 (0.134)	0.242 (0.120)	-0.025 (0.0841)	0.267 (0.0961)	0.403 (0.0848)
Index calibrated to slave states * (slave fraction of population)	1.057 (0.225)	1.519 (0.247)	0.495 (0.176)	1.024 (0.322)	1.387 (0.230)
	[1100]	[1089]	[1089]	[1089]	[1089]

Notes: See notes from Table 2. This table reports results when using the calibrated index for slave population fraction instead of the realization in the regressions.