p-Values on the Free-Slave State Border: A Critique of Bleakley and Rhode

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Abstract

Hoyt Bleakley and Paul Rhode use a "regression discontinuity design" (RDD) to find a persistent negative effect of slavery's legality on rural population density throughout the period from 1790 to 1860. Yet their reported results cannot be replicated. Instead, the replication shows slavery's negative effects only become statistically significant from 1840 onwards. Furthermore, the addition of an interaction term for slavery's legality multiplied by longitude suggests that slavery may have facilitated the westward expansion of the Southern frontier in the antebellum period. This does not support the claim that slavery impeded the growth of American capitalism.

Keywords: economic history, regression discontinuity design, replication, slavery, United States

JEL codes: C21, J47, N11, N21, N51, O43

In a recent paper, Hoyt Bleakley and Paul Rhode (2024) attempt to use econometrics to buttress the argument that slavery impeded the growth of American capitalism. Without explicitly stating what they are doing, Bleakley and Rhode use a "regression discontinuity design" (RDD) to demonstrate slavery's negative impacts on the South. They document in considerable detail the negative correlation between slavery's legality and various rough measures of development at a county level in 1860. Then they provide a figure showing a negative effect of slavery's legality on

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rural population density all the way back to 1790. "The coefficients vary," Bleakley and Rhode (2024, 16) note, but "the general finding throughout the antebellum years is similar to what we report above"—that is, they imply, similar to the negative effects shown in detail for 1860. "Similar results for population density hold in 1840 and before" is how they put it. From this perspective, slavery impeded the South's growth—as proxied by rural population density—*throughout the antebellum period*.

The problem is that these claims are based on a dubious research design and cannot be replicated. This paper begins by detailing how Bleakley and Rhode ignore best practice for an RDD. It then replicates their study but finds little statistical significance in the correlation between slavery's legality and rural population density before 1840. Furthermore, when an interaction term for slavery's legality multiplied by longitude is introduced, it substantially changes the picture. Slavery's effect on rural population density becomes positive beyond an inflection point that moved further westward over time. These results fail to support the story that Bleakley and Rhode wish to tell. Rather, it seems likely that the exploitation of the South's captive labor aided westward expansion in the South, thereby facilitating growth.[1]

I

An RDD is an econometric method that attempts to infer causality from correlation. It looks at either side of a cut-off point where a treatment is applied. If the two sides are otherwise similar, it is possible to use regressions to infer some causality (Athey and Imbens 2017; Cattaneo and Titiunik 2022). In Bleakley and Rhode's (2024) case, the treatment is the legality of slavery and the cut-off point is the free-slave state border. Distance from that border then becomes a running variable that allows the RDD to estimate the effect of passing from free to slave states on various dependent variables, which come from county-level census data.

Bleakley and Rhode (2024, 8, 18) use three equations. The first is:

$$Y = \text{slavery} + \text{longitude} + \text{longitude}^2 + \text{longitude}^3 + \varepsilon \qquad (1)$$

where the dependent variable (Y) in a particular county is the function of a binary dummy variable indicating whether slavery is legal there, with covariates for the county's longitude and its polynomials used as geographical controls, together with the error term (ε). Bleakley and Rhode

[1] Francis (2025b) supports this finding using a more rigorous application of a spatial RDD to farm values per acre, as well as an event study of abolition.

apply this equation to counties adjacent to the free-slave state border and a "donut" sample, which they define as counties whose central point, or "centroid," is within 55 miles of the border but not actually on it. For various wider samples of counties, they add controls for distance from the border and its polynomials:

$$\begin{aligned} Y = \text{slavery} + \text{distance} + \text{distance}^2 + \text{distance}^3 \\ + \text{longitude} + \text{longitude}^2 + \text{longitude}^3 + \varepsilon \end{aligned} \tag{2}$$

Here, then, slavery's legality is the treatment, while the distance from the border is the running variable. These are the basic elements of an RDD, and they are the basic elements of Bleakley and Rhode's paper. In the third equation, they then introduce another element from the RDD methodology:

$$\begin{aligned} Y = \text{slavery} + \text{distance} + \text{distance}^2 + \text{distance}^3 \\ + \text{longitude} + \text{longitude}^2 + \text{longitude}^3 + \text{slavery} \cdot \text{distance} + \varepsilon \end{aligned} \tag{3}$$

where slavery's legality multiplied by distance is an interaction term that allows for a change in the slope of the dependent variable and distance either side of the border. This is now the standard equation recommended in the RDD literature (Athey and Imbens 2017, 5–8), with the addition of the longitude covariates and the distance polynomials as extra controls. What Bleakley and Rhode are doing, then, is clearly an RDD, even if they do not state it or reference the relevant literature.

Bleakley and Rhode then ignore most of what econometricians' consider best practice for an RDD. They do not, for instance, use an algorithm to select their samples based on bandwidths that balance between bias (using data too far from the cutoff) and variance (using too little data). Their approach is to instead arbitrarily choose which distances from the border to use, with a baseline sample covering a massive 600-mile-wide strip of the United States. This obviously complicates their frequent suggestions—not least in the paper's subtitle "Tests at the Border"—that they are looking at slavery's impact at the border. On top of that, they do not use the kernels that more heavily weight observations closer to the border, as is considered best practice in the RDD methodology. And, finally, their visual inspection of the data—the most important part of an RDD—is dubious. Among a plethora of figures, only one presents an actual plot of their data. For 1860, it shows the natural logarithm of farm values per acre on the vertical axis and distance from the border on the horizontal axis, stretching from about 1,000 miles into the slave states and 600 miles into the free states. Superimposed on top of that are what Bleakley and Rhode (2024, Figure 6) describe

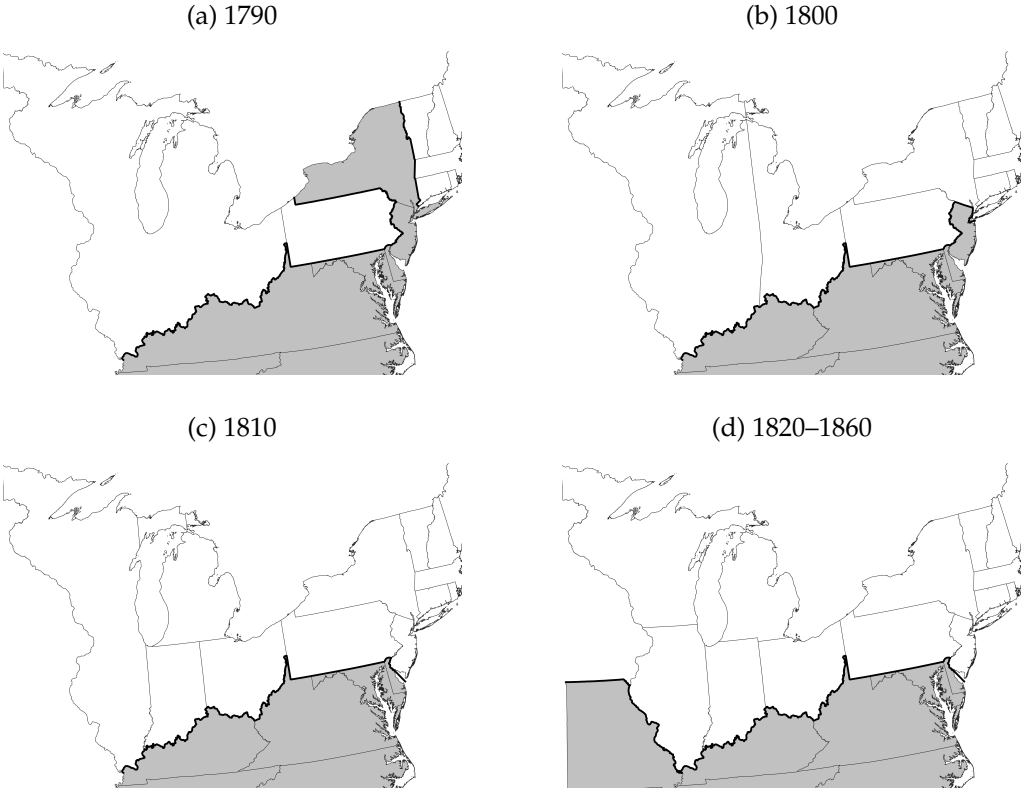
as "estimated quadratic spatial trends," although they do not specify the estimation procedure. They have thus adopted the basic elements of an RDD while ignoring best practice in its implementation—best practice that is intended to minimize the risk of what has become known as "*p*-hacking" (Ritchie 2020).

A red flag raised due to lack of rigor in the research design is then compounded by the results of a replication. Simply put, it suggests that their results lack statistical significance before 1840—that is, in the period for which Bleakley and Rhode (2024, 16) claim "similar results" hold for rural population density as for 1860. The replication was done in R, based on the borders shown in Figure 1, which were drawn in QGIS using the National Historical Geographic Information System (NHGIS) shapefiles (Manson et al. 2022). Equation 1 was then applied to the border and donut samples, and Equations 2 and 3 to the others. Following Bleakley and Rhode, each county was weighted by its area and standard errors were clustered by 15 bins of longitude. The results, shown in Tables 1 and 2, indicate little to no statistical significance before 1840. Rather, slavery's negative effects appear to have been limited to the late antebellum period. There therefore seems to be little evidence that slavery was antithetical to the growth of American capitalism, as Bleakley and Rhode imply. To the extent that it had a statistically significant impact on rural population density, it seems to have begun late in the antebellum period.

On top of that, visual inspection suggests that even the statistically significant results for later years are weak. By applying Equation 3 to log rural population density in their 300-mile "baseline" sample, for example, Bleakley and Rhode (2024, Table 5) obtain a coefficient of –0.509, with a standard error of 0.157 and 1,357 observations, resulting in a *p*-value of 0.0012—virtually at the 0.1 percent level of statistical significance. The replication in R finds a slightly larger coefficient of –0.514 but has a standard error of 0.175, with 1,358 observations, giving a *p*-value of 0.0034; it is slightly higher, but still well below the 1 percent threshold. There is, then, a statistically significant effect, according to conventional measures. That result looks far less convincing, however, when it is shown visually. Figure 2 demonstrates how the data are extremely noisy, with little clear pattern. The dashed vertical line represents the border, with the distance from it on the horizontal axis and rural population density on the vertical axis. For counties in the slave states, the distance from the border has been made negative, which results in them being to the left of the vertical line, while counties in the free states are on the right. Shown in this way, there

Figure 1

The Free-Slave State Border, 1790–1860



Note: Slavery was legal in the gray states and territories; the black line is the free-slave state border. In Panel (d), the state borders are for 1860. They are drawn using shapefiles from Manson et al. (2022).

is no obvious jump up at the border, even if the effect found by the regressions meets the threshold for statistical significance. Even the detailed results that Bleakley and Rhode present for 1860 should therefore be met with some skepticism. Indeed, which is precisely why visual inspection of the data is so fundamental to the RDD methodology: an effect that meets a threshold for statistical significance can mean little in reality, which is a problem endemic to econometrics (Ziliak and McCloskey 2008). In this context, Bleakley and Rhode's decision not to display more of their results visually seems particularly problematic.

Overall, the replication's message is that Bleakley and Rhode's model provides little support for their argument that slavery's legality negatively impacted the South's growth. Their claim that the negative effects they document for 1860 were "similar" all the way back to 1790 cannot be substantiated. Crucially, this means that it is impossible to say whether the negative effects they report for 1860 were actually due to slavery or were

Table 1

Effects of Slavery's Legality, 1790–1860 (Eqs. 1 and 2)

	Border	Donut	300-mile	450-mile	600-mile	900-mile
			(a) Log rural population density			
1790	–0.646**	0.147	–1.056**	–1.237**	–1.278***	–1.278***
	(0.235)	(0.081)	(0.357)	(0.383)	(0.372)	(0.372)
	[57]	[40]	[251]	[278]	[282]	[282]
1800	1.140	0.134	0.050	0.720	0.750	0.750
	(0.577)	(0.223)	(0.396)	(0.608)	(0.609)	(0.609)
	[62]	[42]	[359]	[411]	[415]	[415]
1810	0.191	–0.399	–0.288	0.222	0.604	0.604
	(0.314)	(0.308)	(0.510)	(0.544)	(0.474)	(0.474)
	[63]	[62]	[453]	[547]	[569]	[569]
1820	–0.218	–0.354	–0.766	–0.854	–0.641	–0.641
	(0.254)	(0.301)	(0.497)	(0.540)	(0.522)	(0.522)
	[95]	[103]	[604]	[725]	[755]	[755]
1830	–0.289	–0.303	–0.412	–0.456	–0.751*	–0.666*
	(0.199)	(0.231)	(0.442)	(0.452)	(0.376)	(0.284)
	[108]	[135]	[769]	[931]	[981]	[985]
1840	–0.447**	–0.687**	–0.364	–0.734*	–1.095**	–1.076***
	(0.146)	(0.253)	(0.288)	(0.361)	(0.337)	(0.296)
	[121]	[158]	[1,020]	[1,213]	[1,268]	[1,274]
1850	–0.246	–0.450*	–0.422	–0.869*	–1.118**	–0.503
	(0.139)	(0.201)	(0.233)	(0.389)	(0.433)	(0.508)
	[141]	[200]	[1,196]	[1,425]	[1,528]	[1,584]
1860	–0.282***	–0.550**	–0.516**	–0.659*	–0.893**	–1.388***
	(0.084)	(0.174)	(0.178)	(0.279)	(0.309)	(0.287)
	[144]	[217]	[1,358]	[1,662]	[1,807]	[1,904]
			(b) Log farm values per acre			
1850	–0.349**	–0.652***	–0.448**	–0.562**	–0.558**	–0.655**
	(0.110)	(0.151)	(0.152)	(0.211)	(0.213)	(0.218)
	[141]	[199]	[1,190]	[1,411]	[1,509]	[1,564]
1860	–0.328**	–0.734***	–0.565**	–0.754***	–0.790***	–0.853***
	(0.108)	(0.186)	(0.198)	(0.223)	(0.212)	(0.214)
	[144]	[218]	[1,357]	[1,642]	[1,781]	[1,869]

Note: The coefficients represent the effect of slavery on the indicated dependent variables. The border and donut samples are calculated using Equation 1; the other samples use Equation 2. Standard errors are shown in parentheses and the number of observations in brackets; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Calculated from Manson et al. (2022).

Table 2

Effects of Slavery's Legality, 1790–1860 (Eq. 3)

	300-mile	450-mile	600-mile	900-mile
(a) Log rural population density				
1790	–1.196***	–1.399***	–1.427***	–1.427***
	(0.334)	(0.400)	(0.374)	(0.374)
	[251]	[278]	[282]	[282]
1800	–0.082	0.728	0.724	0.724
	(0.389)	(0.609)	(0.599)	(0.599)
	[359]	[411]	[415]	[415]
1810	–0.316	0.274	0.634	0.634
	(0.512)	(0.562)	(0.493)	(0.493)
	[453]	[547]	[569]	[569]
1820	–0.632	–0.532	–0.341	–0.341
	(0.470)	(0.504)	(0.576)	(0.576)
	[604]	[931]	[755]	[755]
1830	–0.503	–0.548	–0.792*	–0.965**
	(0.397)	(0.426)	(0.402)	(0.309)
	[769]	[931]	[981]	[985]
1840	–0.365	–0.788*	–1.137***	–1.192***
	(0.288)	(0.360)	(0.341)	(0.320)
	[1,020]	[1,213]	[1,268]	[1,275]
1850	–0.429	–0.863*	–1.081**	–0.806
	(0.237)	(0.359)	(0.418)	(0.463)
	[1,196]	[1,425]	[1,528]	[1,584]
1860	–0.514**	–0.660*	–0.907**	–1.433***
	(0.175)	(0.280)	(0.309)	(0.277)
	[1,358]	[1,662]	[1,807]	[1,904]
(b) Log farm values per acre				
1850	–0.454**	–0.565**	–0.557**	–0.656**
	(0.153)	(0.213)	(0.214)	(0.227)
	[1,190]	[1,411]	[1,509]	[1,564]
1860	–0.565**	–0.760***	–0.801***	–0.875***
	(0.199)	(0.223)	(0.212)	(0.215)
	[1,357]	[1,642]	[1,781]	[1,869]

Note: See Table 1 for details.

instead the result of time-variant unobserved confounding variables—that is, something not included in their model that changed over time. If, for example, the North's growth had itself been facilitated by slavery, the causal story that Bleakley and Rhode want to tell falls apart. In this case,

slavery would have allowed the North to grow more rapidly than the South, leading to the negative coefficients found in the later years. For this reason, there are significant endogeneity issues in Bleakley and Rhode's model that need to be addressed.

II

A small addition can also be made to Bleakley and Rhode's model. An interaction term of slavery's legality multiplied by longitude can be added. To demonstrate its importance, Column (a) of Table 3 presents the results of Bleakley and Rhode's Equation 3, applied to the data for rural population density in the 300-mile sample in 1860. The coefficient for slavery is negative and statistically significant at the 1 percent level. It suggests that crossing the free-slave state border was associated with a 51 percent reduction in rural population density. The coefficient for the interaction term of slavery's legality multiplied by distance from the border shows the slope on the slave side, while the distance from the border coefficient is the slope on the free side. Together, they suggest that rural population density tended to increase closer to the border on both the free and slave side, as can also be seen in Figure 2. But it is notable that neither slope is statistically significant. The positive coefficient for longitude, by contrast, is highly significant. It indicates that rural population density became greater the further east a county was.

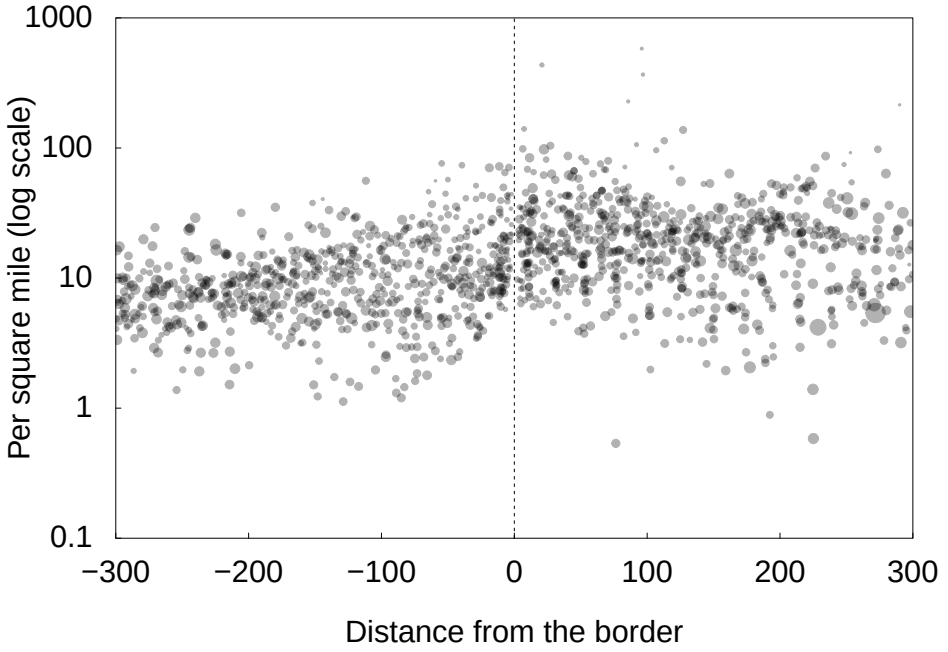
Introducing the interaction term radically changes the results. It is done as:

$$\begin{aligned} Y = {} & \text{slavery} + \text{distance} + \text{distance}^2 + \text{distance}^3 \\ & + \text{longitude} + \text{longitude}^2 + \text{longitude}^3 + \text{slavery} \cdot \text{distance} \\ & + \text{slavery} \cdot \text{longitude} + \varepsilon \end{aligned} \tag{4}$$

In Column (b) of Table 3, the coefficient for slavery's legality now becomes fairly meaningless because it shows the effect of crossing the border at the zero point for the longitude variable, which is at the 96th meridian west, somewhere in Nebraska. The coefficient for the interaction term of slavery multiplied by longitude, on the other hand, is interesting. Its negative sign indicates that on the slave side of the border, slavery's effect on rural population density was less negative—and eventually more positive—as counties became more westerly. Columns (c) and (d) then show the same pattern for farm values per acre—one of the more meaningful dependent variables used by Bleakley and Rhode. In this case, the negative coefficient for the interaction term is also highly significant.

Figure 2

Rural Population Density, 1860



Note: The points show counties, with their sizes set by their area. The distances from the border for counties where slavery was legal have been made negative on the horizontal axis. Calculated from Manson et al. (2022).

Using the coefficients for the interaction term, it is possible to estimate the inflection point beyond which slavery's effect became increasingly positive. It is calculated by dividing the negative of the coefficient for slavery's legality by the interaction term's coefficient. In the case of rural population density, shown in Table 3's Column (b), this means dividing –0.087 by –0.108, then multiplying by 100 to arrive at 81. Based on this calculation, the inflection point was on the Missouri-Iowa border, about 80 miles east of the 96th meridian west. By 1860, then, slavery only had a positive effect on rural population density in some of the most westerly counties in Missouri.

For earlier years, the inflection point was more easterly. This is illustrated by Panel (a) of Figure 3, which shows the location of the estimated inflection points, with the size of the dots indicating the level of statistical significance, while their color reflects the sign and size of their effect. In 1790, the coefficient for the interaction term was actually positive and the inflection point was off the map, far to the east, somewhere in the Atlantic Ocean, indicating that slavery's effect was ever more negative as counties became more westerly. That changed dramatically, however, once the cotton boom began. Already in 1800, the coefficient was negative, large, and

Table 3

Effects of Slavery · Longitude, 1860 (Eqs. 3 and 4)

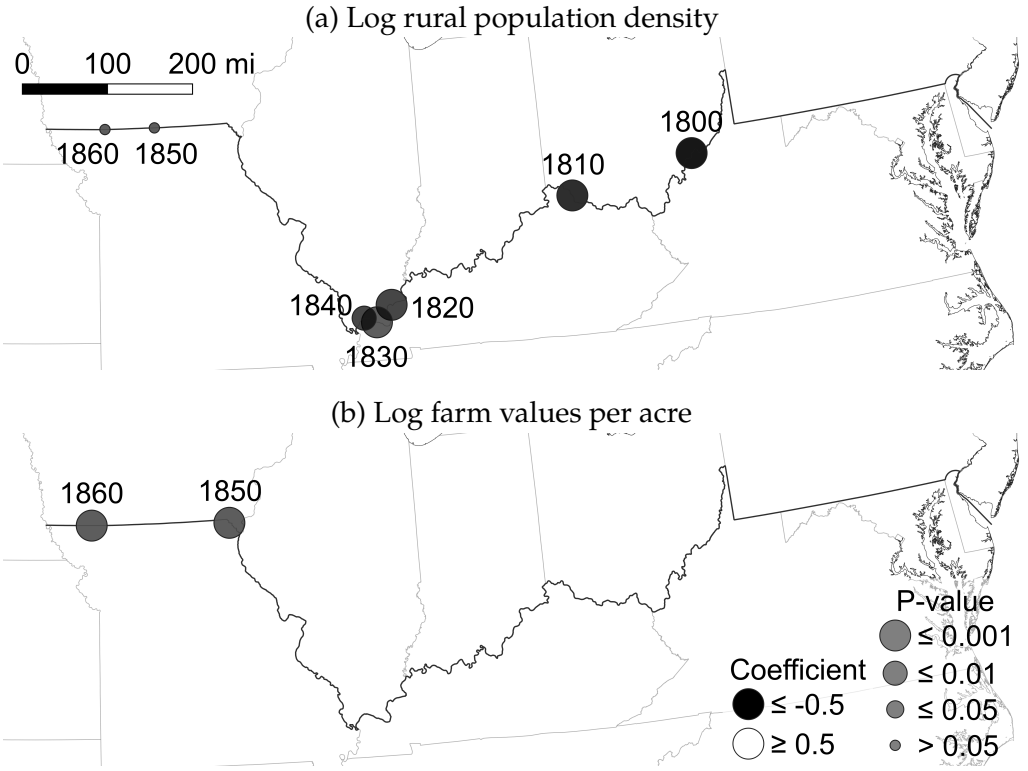
	(a) Log rural population density (Equation 3)	(b) Log rural population density (Equation 4)	(c) Log farm values per acre (Equation 3)	(d) Log farm values per acre (Equation 4)
Slavery's legality	–0.514**	0.087	–0.565**	0.075
	(0.175)	(0.289)	(0.199)	(0.217)
Distance from border	–0.484	–0.478	–0.024	–0.020
	(0.356)	(0.340)	(0.172)	(0.168)
Distance^2	0.043	0.047	–0.016	–0.011
	(0.063)	(0.062)	(0.047)	(0.045)
Distance^3	–0.015	–0.014	–0.021**	–0.021**
	(0.021)	(0.021)	(0.008)	(0.008)
Longitude	1.619***	1.523***	0.550***	0.453***
	(0.412)	(0.360)	(0.103)	(0.081)
Longitude^2	–0.253***	–0.219***	–0.097***	–0.062***
	(0.068)	(0.057)	(0.020)	(0.018)
Longitude^3	0.013***	0.011***	0.005***	0.003**
	(0.003)	(0.003)	(0.001)	(0.001)
Slavery · distance	0.835	0.832	0.323	0.322
	(0.457)	(0.441)	(0.306)	(0.299)
Slavery · longitude		–0.108		–0.115***
		(0.059)		(0.030)
Intercept	0.630	0.485	2.096***	1.936***
	(0.659)	(0.595)	(0.188)	(0.159)

Note: Distance and longitude are shown per 100 miles. Longitude runs from west to east. Each county is weighted by its area and standard errors are clustered by 15 bins of longitude. Standard errors are shown in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Calculated from Manson et al (2022).

highly significant. West of the inflection point on the Ohio-Virginia border, slavery's effect on rural population density was increasingly positive. Up to 1840, it then gradually shifted westward and became smaller and less statistically significant, leading to the rapid shift to the Missouri-Iowa border in the final two censuses of the antebellum period. Panel (b) shows that the pattern was similar for farm values per acre in 1850 and 1860, when the census began to collect those data. Compared to rural population

Figure 3

Inflection Points for Slavery's Effect, 1800–1860



Note: The coefficients and *p*-values are for the slavery · longitude interaction term in Equation 4. Longitude increases from west to east and a negative coefficient in the interaction term indicates that slavery's effect became less negative/more positive the further west a county was. The inflection point is where on the border its effect flipped from negative to positive. It is calculated by dividing the negative of the slavery coefficient by the interaction term's coefficient and multiplying by 100. The border and state lines are for 1860. Calculated from Manson et al. (2022).

density, slavery's effect on farm values per acre seems to have remained more significantly positive.

This finding thus reinforces an assumption that is found in much of the non-economic historiography: that slavery promoted westward expansion. Historians have detailed how Southern planters' desire for more land led first to the Mexican-American War of 1846–1848, and then to the Civil War in 1861 (McPherson 1988, Chs. 2–7; also Torget 2015; Karp 2016; Waite 2021). Reflecting this, the results shown in Figure 3 indicate that the Southern frontier tended to expand more rapidly than in the North. Hence, slavery seems to have had a positive effect on rural population density beyond a certain inflection point, which tended to shift westward over time. That shift seems to have accelerated in the 1850s, which could explain why the

planters were so determined not to be confined to the South once Abraham Lincoln was elected president in 1860 (Clegg and Foley 2019). This is quite a different story to the one reflected in the consensus view of economists today, as reflected in Bleakley and Rhode (2024).

III

Confirmation bias is the likeliest explanation of Bleakley and Rhode's (2024) research design and apparently misreported results. There is a fairly universal human tendency to interpret information in ways that confirm pre-existing beliefs (Nickerson 1998). Bleakley and Rhode (2024) may therefore have been too quick to design their study and interpret its results in a way that supported a narrative that they already believed to be true. This tendency can also be seen, moreover, in how they use Alexis de Tocqueville's observations on Southern backwardness to support their argument. In quoting de Tocqueville, Bleakley and Rhode (2024, 1) are apparently unaware of how confirmation bias affected the French aristocrat's own writings. In total, de Tocqueville spent less than eight weeks in the South during his nine-month stay in the United States and had little interest in witnessing the effects of slavery firsthand. His views on the South were instead shaped by conversations with Northerners and reflected their prejudices (Crouthamel 1982). Bleakley and Rhode then reproduce them almost two centuries later because they confirm their own preconceptions. A similar approach may have been taken to their econometrics.

Rhode was particularly likely to make this mistake because he has publicly committed to the position that slavery impeded the growth of American capitalism. Writing together with Alan L. Olmstead, Rhode has been a prominent participant in the slavery debates. Even if they do not go as far as Gavin Wright (2020, 378; 2022, 123), who accuses the so-called New Historians of Capitalism of repeating pro-slavery ideology, Olmstead and Rhode (2018, 15) still aggressively defend the position that slavery "inhibited economic growth over the long run." They accuse the New Historians of Capitalism of both incompetence and dishonesty. In Olmstead and Rhode's words, their opponents fail "to adhere to the standards and principles long held sacred by historians by making far too many factual errors." The New Historians of Capitalism, they complain, "selectively pluck material from the historical basket to support their views without considering the broader sample of available evidence. In some cases, the authors hide contradictory evidence from their readers." Such

strong rhetoric is unfortunate, and it may have influenced Bleakley and Rhode's (2024) research design and their reporting of its findings. As this paper has documented, that research design is flawed and may not have had the results that Bleakley and Rhode imply.

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