The Slaughter of the Bison and Reversal of Fortunes on the Great Plains *

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Abstract

In the late nineteenth century, the North American bison was brought to the brink of extinction in just over a decade. We demonstrate that the loss of the bison had immediate, negative consequences for the Native Americans who relied on them and ultimately resulted in a permanent reversal of fortunes. Once amongst the tallest people in the world, the generations of bison-reliant people born after the slaughter lost their entire height advantage. By the early twentieth century, child mortality was 16 percentage points higher and the probability of reporting an occupation 19 percentage points lower in bison nations compared to nations that were never reliant on the bison. Throughout the latter half of the twentieth century and into the present, income per capita has remained 25% lower, on average, for bison nations. This persistent gap cannot be explained by differences in agricultural productivity, self-governance, or application of the *Dawes Act*. We provide evidence that this historical shock altered the dynamic path of development for formerly bison-reliant nations. We demonstrate that limited access to credit constrained the ability of bison nations to adjust through re-specialization and migration.

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JEL classification: I15, J15, N31, N32, O10

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"But when the buffalo went away the hearts of my people fell to the ground, and they could not lift them up again." (Chief Crow Plenty-Coups quoted in Lindermann (1930, p. 169))

I. Introduction

At the end of the nineteenth century, the North American bison reached near-extinction after declining from a stock of approximately 8 million to less than 500 (Taylor, 2011). For the Native Americans of the Great Plains, the Northwest, and the Rocky Mountains, this meant the elimination of a resource that served as their primary source of livelihood for over 10,000 years prior to European settlement (Frison, 1991; Gilmore, Tate, Tenant, Clark, McBride, and Wood, 1999; O'Shea and Meadows, 2009; Zedeño, Ballenger, and Murray, 2014). For many Indigenous nations, the bison was used in almost every facet of life and not only as a source of food: skin was used for clothing, lodging, and blankets, and bones were used for tools. Historical and anthropometric evidence suggest that these bison-reliant societies had living standards comparable to or better than their European contemporaries (Carlos and Lewis, 2010; Prince and Steckel, 2003; Steckel, 2010; Steckel and Prince, 2001). When the bison were eliminated, the resource that had underpinned these societies vanished in under two decades.

In some regions, the decline of the bison was a gradual process, beginning with the introduction of the horse and the arrival of European settlers. In other regions, the bison were eliminated through a mass slaughter that occurred within a period of just over ten years.[1] We show that the bison's slaughter resulted in an immediate decline in the material well-being of bison-reliant nations, which has persisted into the present. We argue that the rapid loss of the bison, combined with limited access to credit, altered the dynamic path of development for the formerly bison-reliant nations. This explains a long-standing puzzle regarding the relative poverty of Indigenous nations in the interior of North America today.[2] The experience of bison nations is not just critical for understanding Indigenous outcomes, but also sheds light on the persistent impacts of economic shocks and the institutions that may facilitate recovery.

We begin by showing that the loss of the bison had substantial negative effects for the Native

[1]The slaughter was, at least in part, spurred by an improvement in European tanning technology that allowed bison hides to be transformed into commercially viable leather (Lueck, 2002; Taylor, 2011).

[2]We use the term "Indigenous nation" rather than "tribe" as this language is more accepted globally.

Americans who relied on them.[3] Specifically, we compare nations affected by the slaughter to nations that were never bison-reliant. To establish the contemporaneous impact of the elimination of the bison, we merge our measures of bison-reliance with data on the height, gender, and age of nearly 9,000 Native Americans collected between 1889 and 1903 by physical anthropologist Franz Boas (Jantz, 1995). The nation-age structure of Boas' data allows us to use a difference-in-differences strategy to compare age-adjusted height trends across birth cohorts of individuals affected by the slaughter to those that were not. We find that nations impacted by the slaughter suffered a 2-3 centimeter decline in height relative to nations that were not bison-reliant, effectively eliminating the initial height advantage of bison-reliant peoples before the slaughter.[4]

The negative health effects from the elimination of the bison remain evident in the decades following the animal's slaughter. Using data from the early twentieth century (Ruggles et al., 2015), we find that bison-reliant nations had substantially higher rates of child mortality and skewed sex ratios, both of which indicate maternal deprivation (Almond and Mazumder, 2011; Kraemer, 2000). We show that bison nations also experienced a large-scale occupational displacement. Working-age men in bison nations were 26 percentage points less likely to report an occupation on the 1900 Census of Population compared to Indigenous men that were not reliant on the bison.

Large economic shocks tend to be mitigated by societies' ability to adjust over time; however, rather than converging to the economic outcomes of other Indigenous nations, bison-reliant nations have experienced lower levels of income per capita into the present. We show that these income differences are not explained by differences in baseline characteristics, such as geography or culture, nor by differences in the timing of land cessions, war, railways, or white settlement. They are also not explained by differential application of the *General Allotment Act*, commonly known as the *Dawes Act*, agricultural productivity, or self-governance. Rather, the loss of the bison changed the relative economic trajectory for bison nations, with population, income, and

[3] We use the term Native American to broadly refer to the original inhabitants of North America, but acknowledge that this term is imprecise and is not without controversy (Corntassel and Witmer, 2008). We use it here because of its common acceptance in the United States. In some cases, we also use the term Indigenous.

[4] A 2.5 cm decline in height is substantial. To put this estimate in context, after falling by nearly 4 cm between 1830 and 1890, adult male heights in the United States increased by about 1.8 cm per decade (Fogel, 1984), though the exact magnitude of the decline has been debated (Bodenhorn et al., 2017; Zimran, 2019). Our estimate is approximately half the size of Fogel's estimated height difference between Trinidad-born slaves and the median "well-fed" British person, which he attributes to the effects of malnourishment (Fogel, 1984).

credit markets evolving differently for these nations over the twentieth century. Bison-reliant nations that had relatively accessible credit in the early years of the animal's decline were able to partially adapt through occupational re-specialization and migration. We show that nations that had greater access to credit in 1870 were more likely to enter capital-intensive industries and less likely to enter agriculture, which was encouraged and financed by the Bureau of Indian Affairs (BIA). As a result, bison-reliant nations with greater access to credit have experienced more income convergence over time.

The slaughter of the bison led to one of the largest and most rapid losses of a critical industry in North American history. This specific industrial decline, while important in its own right, is not unlike the losses of other important industries. The decline of the American coal and steel industries in the 1980s (Black, McKinnish, and Sanders, 2003; Obschonka, Stuetzer, Rentfrow, Shaw-Taylor, Satchell, Silbereisen, Potter, and Gosling, 2017), the collapse of the North Atlantic cod fishery in the 1990s (Haedrich and Hamilton, 2000; Milich, 1999), the regional loss of productivity during the Dust Bowl (Hornbeck, 2012), and the decline of manufacturing sector in the early 2000s (Autor, Dorn, Hanson, et al., 2019; Autor, Dorn, and Hanson, 2016) all share similar characteristics. Our findings complement this work and the broader literature that examines why and when one-time shocks can have persistent effects on economic activity.[5] It is increasingly well established that history can impact regional development in ways that are not connected to current fundamentals (Nunn, 2014; Voth, 2021). By tracing the impacts of this exogenous loss of a crucial industry from the late 1800s through 2019, our results offer insights into how one-time economic shocks can influence the distribution of capital and labor and, how local populations for whom geographic mobility is individually undesirable or costly, may end up in impoverished regions over time. We highlight the importance of financial intermediation in assisting economic recovery, particularly for minority populations.

Our work also contributes to a growing literature that offers a counter-narrative regarding the colonization of North America. Much of the existing literature proposes that North America's wealth is a function of Europeans' choice to settle, which brought human capital and technology and led to the development of institutions that promoted growth (Acemoglu et al.,

[5]This is a vast literature which includes, but is not limited to, the work of Acemoglu, Johnson, and Robinson (2001, 2002); Allen and Donaldson (2020); Bleakley and Lin (2012); Caicedo (2018); Dell (2010); Dippel (2014); Hornbeck (2012); Nunn (2008, 2009); Nunn and Puga (2012); Nunn and Qian (2011); Voigtländer and Voth (2012).

2001; Easterly and Levine, 2016; Nunn, 2014). However, Europeans were not importing their institutions or bringing their human capital to a blank slate; Indigenous institutions, resources, and industries were undermined in the process.[6] In light of this, the reversal of fortunes we document provides a novel explanation for the geographic clustering of poverty observed among Indigenous communities in North America.[7] We see this as a first-order contribution to understanding the processes that have resulted in the Native American communities of the Great Plains having some of the lowest incomes in the United States.

II. A Brief History of the Bison's Decline

Before European settlement, between ten and thirty million bison roamed the territory enclosed by the Rocky and Appalachian Mountains, the Mexican states of Chihuahua and Coahuila and the Canadian Northwest Territories (Hornaday, 1889; Lueck, 2002; Taylor, 2011). Anthropological evidence suggests that Indigenous peoples in these regions hunted the bison for at least 10,000 years prior to contact (Frison, 1991; Gilmore et al., 1999; O'Shea and Meadows, 2009; Zedeño et al., 2014).

Archaeological records indicate that many bison-reliant peoples were highly specialized in their economic activity, even though other resources were present, suggesting that the bison provided a reliable source of food and wealth (Daschuk et al., 2006; Zedeño et al., 2014). Nearly every part of the animal had a use. Hides were softened and tanned for clothing, blankets, art, and lodging. Brains were used as grease for tanning hides, bones formed tools, marrow was consumed for its nutritional content, and stomachs were converted into bags or vessels. Bison meat was often dried for preservation, or it was combined with processed berries and bison fat to produce a mixture called pemmican. Enclosed in a bag made from the bison's stomach, pemmican could be stored for years and sustained the bison nations during times of food shortages.

Due in part to the plentiful nature of the bison and the ability to store its food products

[6] See Akee (2009); Akee, Jorgensen, and Sunde (2015); Akee, Spilde, and Taylor (2015); Anderson and Parker (2008, 2009); Aragón (2015); Carlos, Feir, and Redish (2021); Cornell and Kalt (2000); Dippel (2014) for a discussion of institutions, Feir (2016); Gregg (2018) for a discussion on human capital, and Aragón (2015); Leonard and Parker (2017); Leonard, Parker, and Anderson (2020) for a discussion of land and natural resources.

[7] For a discussion of the geographic distribution of poverty in Canada and the United States see AANDC (2015); Anderson and Parker (2009); Hurst (1997).

for years, the bison peoples were some of the wealthiest peoples in North America and arguably as well-off as their European counterparts (Carlos and Lewis, 2010; Prince and Steckel, 2003; Steckel and Prince, 2001). While early anthropologists often characterized bison hunting societies as egalitarian and lacking organizational complexity; recent work by anthropologists suggests that bison-reliant societies had well-defined systems of ownership over hunting grounds, permanent sites of residence, complex kinship networks, and economic power relationships designed to secure the best bison herds (Zedeño et al., 2014). Bison societies also cultivated the short grasses preferred by the bison to encourage its flourishing (Isenberg, 2000; Zedeño et al., 2014).

While methods of hunting and employing the bison evolved over time, from spears and dogs to archery, the largest change occurred when the horse was introduced to North America. Horses spread from Spanish-controlled regions of South America to as far north as Canada, likely through pre-existing Indigenous trade routes (Hämäläinen, 2003). By the 1650s, colonists had become aware of mounted Native Americans after encountering the riders of the Apache. The introduction of the horse decreased the costs associated with hunting bison, leading some societies to shift from agriculture towards bison hunting as their main source of economic activity (Gwynne, 2010); however, it also brought the first waves of European diseases, infecting the people of the Great Plains through their contact with Native horse traders who had been exposed to Europeans (Daschuk, 2013).[8] The earliest contact bison-reliant societies had with the English and French was indirectly through the fur trade. Bison robes and pemmican were traded, although neither commodity was as lucrative as the furs being sought for resale in Europe. Bison-reliant peoples had been tanning hides for centuries, but the process was labor intensive and unprocessed leather from bison hides was not commercially viable from a European perspective (Taylor, 2011).

As settlement moved westward, the bison were hunted at higher rates which, when combined with years of drought and competition for food sources from settler cattle, slowly began

[8]The extent to which Plains peoples were depopulated by European diseases has been intensely debated (Cameron, Kelton, and Swedlund, 2015). Early estimates suggest that, between 1774 and 1839, depopulation among Plains Natives was in the realm of 50%-60% (Decker, 1991), but later estimates suggest that this figure may be closer to 20% (Carlos and Lewis, 2012). Some historians have suggested that depopulation among the peoples of the Great Plains did not occur until *after* the extermination of the bison, when bison-reliant societies were on the brink of starvation and vulnerable to disease from malnutrition (Cameron et al., 2015; Daschuk, 2013; Daschuk et al., 2006).

depleting the bison populations east of the Mississippi (Isenberg, 2000). The pace of the bison's extermination drastically increased with the construction of the Union Pacific Railroad between 1863 and 1869. Upon completion of the railway, settlers had access to the herds of the interior in an unprecedented manner (Hanner, 1981; Hornaday, 1889). Even so, historical accounts suggest that settlers and Indigenous communities did not anticipate the bison's rapid extermination (Daschuk, 2013; Hanner, 1981). In fact, the construction of the railway through the Great Plains was made possible because of a series of treaties the United States negotiated during the late 1860s with the Apaches, Cheyenne, Kiowas, and the Comanche in the south, and North-Western Sioux and Northern Cheyenne—specifically the Teton Sioux, known as the Lakota—in the north.[9] Through these treaties, nations exchanged large tracts of their ancestral territories for public goods, annuities, and protection of their exclusive right to hunt the bison herds. Many of the treaties included clauses that protected the bison from being hunted by settlers, which had resulted in a gradual decline of the herds in other areas of the country (Gwynne, 2010).

The fate of the bison changed in 1871 when tanners in England and Germany developed a commercially viable method of tanning buffalo hides (Taylor, 2011). The European demand for hides spiked and, in response, hide hunters flooded bison territory. Taylor (2011) estimates that in 1875, 1 million bison hides were shipped from the United States to France and England alone. The hide men initially focused on the more accessible southern herd, and by the spring of 1874, the herds on the middle plains had been decimated. A country once "black and brown with bison was left white by bones bleaching in the sun" (Gwynne (2010), p.260-261). By 1879, the southern herd was completely eliminated (Hornaday, 1889).

Several scholars have argued that the slaughter of the bison would not have happened in an environment with well-defined property rights (Benson, 2006; Hanner, 1981; Lueck, 2002; Taylor, 2011). As far as the Native nations were concerned, property rights existed through signed treaties and those rights were simply not protected. However, American military commanders believed that Native people would not be truly settled onto reservations until the bison were exterminated (Smits, 1994). Generals actively encouraged their troops to kill the bison for food, sport, or "practice". MacInnes (1930) argues that American soldiers drove bison herds

[9] These treaties include, but were not limited to, the Medicine Chest Treaties of 1867 in the South and the Fort Laramie Treaty of 1868 in the North.

south into the region of the hide hunters. According to estimates compiled by Taylor (2011), hide exports from the northern herd were one tenth of those of the earlier southern slaughter. One explanation for this is that after the slaughter began in the south, the American military saw it as an opportunity to weaken nations and their corresponding treaty rights and began to participate in the slaughter without commercial intentions. The bison were exterminated in northern Montana and Saskatchewan by 1878; in Wyoming and Alberta by 1880; the last bison hunt by the Sioux was in 1882 (Ostler, 2001); and the last bison in the remaining territory was gone by 1883 (Hornaday, 1889).

In less than two decades, the economic and social core of the great bison nations was gone. By the early 1880s, there were no bison, little game, and inadequate or non-existent government food supplies. Records from trading posts, Native leaders, Indian Affairs officials, and media outlets reported widespread malnutrition and hunger among the Native populations (Cameron et al., 2015). Communities resorted to eating horses, mules, soiled food, and old clothing to prevent starvation (Daschuk, 2013; Gwynne, 2010). The resource that underpinned centuries of human capital acquisition was eliminated with few alternative options. Some communities resorted to collecting bison bones that littered the plains after the slaughter and selling them for fertilizer (Ostler, 2001).

Economic activity and mobility were severely constrained during this time period and left few dimensions along which Native Americans could adjust, at least initially. Native Americans in the United States faced strict constraints on their freedom of movement over the latter half of the nineteenth century and the beginning of the twentieth century (Adams, 2006; Gundlach and Roberts, 1978; Marks, 1998; Sorkin, 1969). While not as well-documented as its Canadian equivalent, Native Americans generally required permission from an Indian agent to leave the reservation and departures were discouraged (Seaton and Bennett, 2008). It was only with the passage of the Indian Citizenship Act in 1924 that Indigenous peoples were granted free movement within the United States, but this applied only to those born after 1924 (Snipp, 1997). It was not until the passage of the Nationality Act of 1940, that Native American freedom of movement was confirmed (Haas, 1957). As such, at a minimum, Native Americans in impacted regions only practically gained the ability to adjust through migration several decades after the bison's slaughter and even then migration may have been difficult.

The ability to adjust to alternative occupations to bison hunting may have also been constrained. Cattle ranching, a plausible alternative use of skills and land for many bison peoples, was initially difficult to enter because of resistance from Indian Agents or credit constraints (Iverson, 1997; Trosper, 1978). Agriculture was effectively the only economic activity supported or promoted by North American governments despite the cultural norms and limited historical experience by the formerly bison-reliant nations (Gwynne, 2010; Iverson, 1997; Ostler, 2001). Later, we discuss the importance of access to credit in more detail as it pertains to the ability of bison-reliant nations to adjust to its loss in the following decades.

III. Data and Summary Statistics

In order to understand how the slaughter of the bison impacted communities that had relied on it, we need to measure which nations depended on this resource at the start of the slaughter, the speed at which the resource was lost, and economic outcomes over time. This section briefly describes the construction of the main measures of exposure to the bison's slaughter, the cultural, geographic, and colonial experience control variables, and the construction of the primary economic outcomes. A more detailed description of all sources, variables, and data construction procedures, can be found in Section **??** of the Online Appendix.

In an ideal world, we would know when each nation lost the bison from its territory and whether the loss was anticipated. To our knowledge, there is no comprehensive source of this timing for all nations. The most detailed account of the bison's slaughter and general decline is by Hornaday (1889) and allows for the identification of nations that were geographically proximate to the bison range at the start of the rapid slaughter.[10] A digital reproduction of Hornaday's map can be found in Figure 1.[11] The beige (outer) region represents the bison's range as of 1730, the brown (middle) region is the bison range at the beginning of the slaughter in 1870, and the black (inner) regions are the remaining herds, found only in captivity, after the slaughter ended in 1889.

We use Hornaday's map to identify whether a nation's traditional territory overlapped with

[10] William Hornaday was commissioned by the Smithsonian Institute, at the end of the nineteenth century, to construct a detailed account of the North American bison and its elimination. As part of an extensive monograph, Hornaday published maps of the original bison range and, importantly for our purposes, defined its remaining range at the start of the rapid slaughter.

[11] An image of the original map is located in Figure **??** of the Online Appendix.

the geographic range of the rapid slaughter by overlaying our digital reproduction of it with separate reproductions of regional ancestral territory maps from Martin and O'Leary (1990).[12] From the intersection of these maps, we construct an indicator that equals one if any of the nation's ancestral territory overlapped with the geographic range of the rapid slaughter and zero otherwise.

It is important to recognize that this calculation alone is insufficient to identify bison-reliance, as it depends solely on geography. The degree of bison-reliance among Native Americans, even in areas that were densely populated by bison, varied markedly. For example, the Mandan peoples lived in the bison-dense territory of what is now North Dakota, yet they relied predominantly on agriculture and traded for bison meat and other supplies (Fenn, 2014). Using this simple geographic proxy would identify the Mandan as fully bison-reliant and among those that were exposed to the slaughter. In order to avoid this type of misclassification, we construct an indicator for historic bison reliance from the anthropological accounts in the fifteen volumes of the Smithsonian Handbook of North American Indians (Sturtevant, 1981). This indicator equals one if bison is listed as one of the primary food sources and zero otherwise.[13]

Our primary measure of exposure to the slaughter combines elements of the timing and speed of the bison's decline from Hornaday's accounts with elements of the anthropological records of bison reliance from the Smithsonian books. We define treatment as equal to one if the nation's ancestral territory overlapped with the geographic range of the rapid slaughter *and* the nation relied on the bison for a significant part of their consumption. The control group consists of nations that were never bison-reliant. We maintain this consistent definition of treatment ("Exposed to Slaughter") and control ("Not Bison-Reliant") throughout the empirical analysis.[14]

In the empirical analysis that follows, we trace the economic trajectories of bison-reliant nations across the nineteenth, twentieth, and twenty-first centuries relative to nations that

[12] This map is depicted in Figure **??** of the Online Appendix.

[13] While it is also possible to construct an index of whether a community was diversified or specialized in their use of the bison, in practice, within the rapid slaughter region, the vast majority of bison nations were highly specialized. Thus, we focus on a simple binary indicator here.

[14] Specifications using alternative control groups tend to yield larger estimates of the treatment effect. Specifically, we have estimated models where the control group is comprised of: 1) nations that were not bison-reliant but whose traditional territory overlapped with the original bison range; and, 2) nations that were not bison-reliant but whose traditional territory was outside the rapid slaughter region yet overlapped with the bison's original range. These results are unreported but available upon request.

were not bison-reliant. Doing this necessitates the use of data from multiple sources, all of which must be matched with our indicators of historic bison reliance. Further, we match the outcomes of interest to additional measures of cultural norms, geographic conditions, and colonial experiences. .

Table 1 presents key descriptive statistics for nations that were exposed to the slaughter and those that were never bison-reliant.[15] Panel A shows that the bison nations were fairly distinct. They were more likely to be fully or semi-nomadic than communities that were not bison-reliant. They generally had fewer wealth distinctions than other groups and had larger populations as of 1500, but were comparable in terms of how centralized their historic community governance structures were. Bison-reliant nations were located in areas that had less rugged terrain. Given the differences in the pre-slaughter cultural and colonial experiences of bison nations relative to those that were not bison-reliant, it is important that empirical specifications control for such pre-existing factors when nation-level fixed effects cannot be used.

We use several data sets to measure economic outcomes pre-1870 and shortly after the slaughter ended. Given the absence of comprehensive income and occupational data for Native Americans prior to 1900, we measure the immediate effects of the bison's decline using anthropometric evidence on childhood and adult height as biological indicators of well-being (Steckel, 1995, 2008). These data were collected between 1888 and 1903 by a team of anthropologists led by Franz Boas. The data include measures of height, sex, age, nation and "racial purity" for approximately 15,000 Native Americans in nearly all areas of North America (Jantz, 1995). Panel B of Table 1 displays these statistics for Boas' sample. The first row presents the average height for the full sample. The next two rows present the average height for men born before 1870 and the third row for women born before 1870. Relative to the reference group, male and female bison-reliant community members were 2.72 cm and 2.69 cm taller, respectively. Enumerators were equally likely to record individuals from bison nations and nations that were not bison-reliant as having only Native American ancestors (coded as "full blood" in the data). Bison nations were slightly older and less likely to be female.

We supplement Boas' data with additional biological indicators of well-being available from

[15] A description of the full list of variables can be found in Section ?? of the Online Appendix with summary statistics in Table ??. This table presents all possible alternative control groups. Two important takeaways from these comparisons are that the alternative control groups are not substantially different from one another and that all control groups are systematically different from bison nations.

the 1900 IPUMS over-samples of Native Americans (Ruggles, Genadek, Goeken, Grover, and Sobek, 2015). As direct measures of mortality we use data reported by mothers on the proportion of children ever born who survive. We also consider the number of children ever born, since fertility rates may change in response to elevated child mortality. As a final measure of biological well-being, we use an indicator that equals one if an individual is female and focus on the sample of individuals who were born at the start of the rapid slaughter (1871) and after the bison were effectively eliminated (1886). This exercise is useful in evaluating maternal deprivation, as the relative fragility of male neonates and fetuses means they are less likely to survive during times of hardship (Almond and Mazumder, 2011; Kraemer, 2000). Since, for men, the loss of the bison can be viewed as the loss of a primary occupation, we also use the 1900 over-samples to examine standardized occupational rank and the probability of reporting an occupation (Ruggles, Genadek, Goeken, Grover, and Sobek, 2015).

Panels C and D of Table 1 present summary statistics for these additional outcomes of interest. Statistics for women who became of childbearing age after the start of the slaughter (born after 1857) are found in Panel C of Table 1 and statistics for men of working age (between 20 and 65) in Panel D of Table 1. The first row of Panel C reports the proportion of children born who survive. Among bison nations, seven percentage points fewer children survived, although slightly more children were born in total. Women exposed to the slaughter were slightly older, and had less white ancestry, as perceived by a census enumerator. In the first row of Table 1, Panel D, we see that bison-reliant men had a notably lower occupational rank. This is expected, given the next row, which shows that bison-reliant men were 35 percentage points less likely to have an occupation. Men in the bison nations were also less likely to work in agriculture. Like women, they were older and had less white blood, as perceived by the enumerator.

To measure the persistent effects of the bison's decline on economic outcomes, we use the reservation-level panel constructed by Leonard et al. (2020), which contains Native American per capita income from several sources: the BIA in 1945, the decadal U.S. Censuses in 1970, 1980, 1990, and 2000, and the 2007-2012 American Community Surveys. We update these data with income per capita from the American Community Surveys for the 2015-2019 period. All income measures are constructed at the reservation level and for Native Americans living within their boundaries. We present income in 2010 dollars, adjusted by the national CPI.

The Leonard et al. (2020) dataset includes additional variables on forced co-existence—the tendency for some reservations to be comprised of nations without a shared history of governance—from Dippel (2014) and importantly, whether a reservation was ever allotted under the *Dawes Act* of 1889 (a process which ended in 1934), as well as the amount of acres with fractionated property ownership that was a consequence. We supplement these data with the additional sources that are used to augment the Boas and IPUMS data, and also make use of a number of additional data sources to evaluate the mechanisms that explain the persistence of the shock, to which we return in Section VI. For any variables that are measured at the nation-level, we first link nations to reservations, where in some cases reservations are associated with more than one nation. In these cases, we either average values over all nations on a reservation or we use the minimum or maximum values if they are more appropriate.

IV. The Impact of the Bison's Decline: Contemporaneously and in the Decades Following the Slaughter

We begin our empirical analysis by considering the impact of the bison's near-extermination on a range of outcomes available contemporaneously and in the decade following the slaughter. In the period immediately surrounding the slaughter, we rely on anthropometric information on the heights of individuals. In 1900, we consider measures of child mortality, fertility, population sex compositions, and occupations.

We use Boas' anthropometric data in a difference-in-differences estimation strategy based on a person's year of birth and the bison-reliance of their nation. We let i denote the individual, n the native nation, t the cohort, and H_{int} the height of the individual in centimeters. Our estimating equation for the immediate effects of the loss of the bison can be written as:

$$\mathrm{H}_{int} = \beta \mathbb{1}(\mathrm{BornNoBison}_t) \times \mathrm{B}_n + \mathrm{X}_{int}\boldsymbol{\theta} + \gamma_n + \alpha_t + \varepsilon_{int}, \quad (1)$$

where bison-reliance is given by B_n, and is defined above, and $\mathbb{1}(\mathrm{BornNoBison}_t)$ is an indicator for the individual being born after the bison were eliminated. For all practical purposes, the bison were eliminated by 1886.[16] The coefficient of interest is β, which is the coefficient on the

[16] The last known bison was eliminated from Lakota territory in 1883 (Hornaday, 1889). We choose a cutoff

interaction of bison-reliance and the indicator for being born after the bison were eliminated. We include a full set of age fixed effects, α_t, to control for age-trends in height and a full set of nation-level fixed effects, γ_n, to control for nation-level unobservables that may influence biological well-being. We also condition on a matrix of controls, X_{int}, which includes survey year fixed effects, and five-year birth year cohort fixed effects, as well as indicators for whether the individual is full blood, female, born during a major war with the United States, the settler population density in their traditional territory during the decade in which they were born, whether their nation had ceded their land to the US at the time of their birth, whether there was a railway in their traditional territory when they were born, and a set of fixed cultural and geographic controls interacted with birth year to account for secular trends in birth cohort height that may vary with pre-determined characteristics.[17] To reduce concerns related to selective mortality among older adults, all specifications focus on those born after 1850. Standard errors are clustered at the nation level.

The results of estimating equation 1 are presented in Table 2. Panel A uses standing height in centimeters as the dependent variable and Panel B uses the 2006 World Health Organization (WHO) height-for-age by sex z-scores. The first column presents results from specifications that only condition on individual-level controls, the second includes cohort-nation-varying controls. The third and fourth columns replicate (1) and (2) for individuals between the ages of 5 and 20 years of age. Columns (5) and (6) include all controls and separate effects by men and women, respectively.

The summary statistics in Table 1 show that, prior to the slaughter, nations that were exposed to the slaughter were about 2.7 cm taller than those that were not bison-reliant. Panel A of Table 2 shows that after 1886, *nearly their entire height advantage* was eliminated, with declines in height of up to 2.9 cm more for bison-reliant nations relative to nations that were not bison-reliant.[18] Panel B of Table 2 confirms this conclusion using the WHO height-for-age by

based on a three year delay as pemmican can last for up to three years after being preserved (Hornaday, 1889).

[17]Cultural and geographic controls include and indicator for whether a nation was nomadic, the log of their population as of 1500, whether they were historically centralized, whether they had wealth distinctions, and whether a nation is missing a value for any of these characteristics, the log ruggedness of their traditional territory, their latitude, and the log area of their traditional territory.

[18]We have also estimated specifications that allow us to infer the effect of an additional growing year spent after the slaughter. These results suggest that for nations that were exposed to the slaughter, an additional year between the ages of zero to twenty-one without the bison would reduce one's height by 0.45 cm relative to nations that were not reliant on the bison.

sex z-scores in place of height in cm to account for the fact that many individuals in our sample, particularly after the slaughter, may not have reached terminal adult height. This adjustment introduces additional noise, in part because we do not have age in months, and further, because age may be noisily reported. Even so, we find that the height-for-age of bison-reliant nations declined by 0.32 standard deviations more relative to the height-for-age of nations that were not bison-reliant. This is also true when we restrict the sample to a more narrow range of ages, 5 through 20, in columns (3) and (4).[19]

The key assumption required for identification in our difference-in-differences specification is that the height trend of bison-reliant nations would have been the same as nations that were not bison-reliant were it not for the bison's slaughter. While we cannot formally test this parallel trends assumption, we can evaluate its validity using an event study framework that interacts each 5-year birth cohort with the treatment indicator for bison reliance. Figure 2 displays coefficient estimates and 90% confidence intervals from this exercise for the height-for-age Z-scores for the full sample.[20] Each coefficient represents the differential change in heights of bison-reliant nations relative to nations that were not bison-reliant after 1870, the year before the slaughter began, depicted by the red dashed line. The light gray dashed line depicts the year 1886, which is the year that bison food products were no longer available. The coefficients for cohort groups born before the start of the slaughter act as a placebo test for whether the parallel trends assumption holds.

The first set of estimates in Figure 2, represented by black squares, are from a specification that accounts for age dummies, sex, an indicator of appearing to not have white ancestry to an enumerator, event time, and nation fixed effects. Reassuringly, all of the pre-treatment estimates are both small in magnitude and statistically insignificant. These results strongly suggest that there were no differential trends in heights among the cohorts born prior to the disappearance of the bison, lending credibility to the difference-in-differences specification. Nevertheless, because of the appearance of a slight upward trend in the pre-treatment period estimates, our second

[19]The lack of data on age-by-month and the potential inappropriateness of using modern height for age scores for historical populations may bias the results using the WHO z-scores. For example, the average individual in our sample has a height-for-age that is over one standard deviation below the WHO mean height for age. Regardless, the results using this adjustment support the same conclusion, that the loss of the bison had significant impacts on the biological stature of the Native nations that relied on them.

[20]All coefficient estimates are reported in the Online Appendix Table ??. We also present the event study for height in centimeters in the Figure ?? and Table ?? of the Online Appendix.

empirical specification allows for the possibility of a differential linear pre-trend in the heights of bison nations. Estimates from this specification are depicted by the medium gray circles in Figure 2. Our third and final specification adds the controls for colonial experiences, geographic differences, and cultural factors, and their interactions with birth-year, as described in the previous section. These are depicted by light gray diamonds. In all three specifications, there is a downward trend in age-adjusted heights after the start of the slaughter. Our preferred specification is the second one, which allows for linear pre-trends and controls for age and nation fixed effects. In this specification, the relative decline in the age-adjusted heights of bison nations is statistically significant at the 10% level both five and twenty years after the start of the slaughter. Moreover, the point estimates consistently indicate that, among the cohorts of individuals born after the slaughter, the heights of bison nations declined relative to those of non-bison nations. The final specification, which includes a demanding set of controls and their interactions with birth-year, has larger standard errors in the last period compared to the other specifications, but the point estimates are qualitatively similar, suggesting the relative decline in the heights of bison nations is robust to an extensive set of controls in an event-study design. Overall, these results show that, after the start of the slaughter, bison nations experienced a substantive decline in biological well-being.

There are two primary caveats related to the use of Boas's data. The first relates to survivorship bias. As noted by Bozzoli et al. (2009), if potential height is distributed in the population according to an underlying CDF, $F(h_p)$, and children less than some potential height, h_p, cannot survive, then we would *under-estimate* the effect of the slaughter of the bison on height. In fact, we can see from the age distributions in Figure **??** of the Online Appendix that the bison nations had notably fewer children than nations that were not bison-reliant, consistent with elevated rates of child mortality among bison nations. Unfortunately, Boas' sample was not designed to estimate population sizes by cohort. As such, forming estimates of mortality by cohort and nation is not possible.[21] As a consequence, we are unable to estimate a model such as in Bozzoli et al. (2009). However, in what follows, we use data from 1900 to estimate child mortality, among other outcomes. These estimates allow us to generate bounds on the degree of selection due to mortality, which we discuss in more detail below.

[21]Even data from Indian Affairs reports, when available, is at best aggregated at the nation level and not available by birth cohort.

Our second caveat relates to selection into the heights data based on unobserved confounders. Recent work comparing the Cherokee in Boas' sample to the Cherokee census suggests that the Boas sample is representative on average, but that it may over-represent the upper and lower classes (Miller, 2016). The Cherkoee are likely to be different from the average Native American nation for a number of reasons, so generalizing from Miller (2016) to the entire Boas sample may be inappropriate. Further, other scholars have questioned the representativeness of Boas' sample specifically (Komlos and Carlson, 2014), and of height data more generally (Bodenhorn, Guinnane, and Mroz, 2017).[22] What is important for our empirical strategy is that, conditional on our set of covariates, over- or under-representation does not vary differentially across birth cohorts that were exposed to the slaughter and those that were not bison-reliant. Even so, concerns about the Boas data source itself and the reliability of heights as an indicator of well-being may remain. Thus, next we present an analysis of child mortality, fertility, sex bias, and occupational outcomes available in the IPUMS 1900 historical over-sample.

Unfortunately, the structure of the over-samples data do not permit a difference-in-differences style analysis, so we conduct a cross-sectional analysis that relies on the assumption that exposure to the slaughter is conditionally uncorrelated with other omitted factors that may also be related to our outcomes of interest. All specifications control for a quadratic in individual age, and a set of historical geographic controls including ruggedness of traditional territory, latitude, census region fixed effects, and year dummies. We also condition on the set of cultural controls and the cohort-nation varying colonial experience controls.

In specifications that examine mortality and fertility, we restrict our sample to be mothers who would have been coming of childbearing age (14) at the start of the rapid slaughter and then to mothers born after the start of the slaughter. When examining the sex distribution, we again use OLS specifications and restrict the sample to be all people born after the start of the slaughter, followed by those born after its end. When examining occupational outcomes, we focus on men between the ages of 20 and 65.

[22]Bodenhorn et al. (2017) suggest a simple way to check for age-related selection. Although their analysis is primarily concerned with selection in heights data from military enlistments, this could also be a problem in our analysis if, for example, the tallest (strongest) bison-reliant peoples were sampled in Boas' first survey waves and the shortest (weakest) in later years. The test amounts to verifying that, conditional on reaching adult height, average heights are the same for individuals who are from the same birth cohort but surveyed in different years. In Appendix Figure **??**, we plot height-age trends by birth cohort and show that this is likely not a problem in Boas' sample.

Panel A of Table 3 presents the results for the additional measures of biological well-being. The first two columns display the results for the proportion of children ever born who survive. Column (1) shows that, among women of childbearing age, those who were exposed to the rapid slaughter had 10 percentage points fewer children who survived relative to women who were not bison-reliant. Restricting the sample to mothers who were born after the start of the slaughter (2) increases the coefficient estimate to 15.5 percentage points. These estimates provide direct evidence that mortality was higher in bison societies following the start of the slaughter. Columns (3) and (4) show that bison communities did not increase fertility in response to higher mortality. Finally, we show that cohorts born after the start of the slaughter (5) and those born after the bison were gone (6) were about six and nine percentage points more likely to be female, respectively. This evidence is consistent with mothers experiencing deprivation that would disproportionately impact male fetuses and neonates due to their biological vulnerability (Almond and Mazumder, 2011; Kraemer, 2000).

Taken together, the results for heights, mortality, fertility, and sex are consistent with bison-reliant nations experiencing a substantial decline in biological well-being after the bison's decimation. However, turning to the first caveat related to the interpretation of the heights specifications, the increases in child mortality suggest that the height effect we estimate may be a lower bound of the true anthropometric consequence of the loss of the bison. Alternatively, if bison nations responded to the lack of food by diverting consumption from the weakest members of the older cohorts to those in the youngest cohorts, then our estimates would represent an upper bound on the true effects if the mortality burden was greater among older cohorts. We formalize these bounds more explicitly in Online Appendix Table **??**. We use a mortality estimate of 15 percent which is in the upper range of the child mortality rates estimated in Table 3 and then compute treatment effects under various assumptions about the counterfactual heights of those who ultimately did not survive. Panel A of Table **??** performs this exercise when we assume that mortality occurred in the youngest cohorts, while Panel B of Table **??** performs the exercise when we assume that mortality occurred in the oldest cohorts. As an example of how to interpret these bounds, if we assume that those who died would have been in the 20th percentile of the heights distribution of the remaining individuals, then we can bound the estimated treatment effect of -2.62 cm (column (1) of Table 2) between -3.5 cm and -2.02

cm.

Beyond direct health outcomes, we examine the occupational consequences for men in Panel B of Table 3. We display results for all working age men in odd columns and for men born after the start of the slaughter (1871) but of working age by 1900 in even columns. This allows us distinguish whether men who were born into the bison occupations were the only ones affected or whether men born after bison-related occupations became obsolete were also affected. The first two columns focus on the standardized occupational score. Bison-reliant men had systematically lower occupational scores relative to men who were not bison-reliant. The estimate for younger men is only slightly smaller. The next two columns show that men from bison nations were about 19 percentage points less likely to report having an occupation. Columns (5) and (6) focus on the occupational score of individuals, conditional on reporting some occupation. These results confirm that, for both comparisons, the overall lower occupational rank in columns (1) and (2) is due to a differential propensity to report no occupation.[23]

The evidence from this section suggests that the slaughter of the bison was a biologically and economically meaningful loss to the nations that relied on them. Any height advantage that the bison nations had prior to the slaughter was lost by the end of the nineteenth century. Even if one is skeptical of the data on height, data from the United States Census suggests that at the start of the twentieth century, bison nations had elevated rates of child mortality and maternal deprivation relative to Indigenous nations that were not bison-reliant. At the turn of the twentieth century, working-age men from bison nations were much less likely to have an occupation relative to men from nations that were not bison-reliant.

V. The Persistent Impact of the Bison's Decline

We next ask whether the formerly bison-reliant nations adjusted to the loss of their principle economic resource over the course of 150 years. Our empirical specifications are OLS regressions

[23]The estimated treatment effects for occupational outcomes are substantially larger when the comparison is between men from bison-reliant nations and geographically proximate whites (see Online Appendix Table **??**). Importantly, regardless of the comparison group, the occupational results are not due to census enumerators systematically being more likely to leave the occupation field blank for formerly bison-reliant nations. Enumerators were actually less likely to leave the occupation field blank for bison-reliant men relative to Native men that were not bison reliant, and they were equally likely to leave this field blank compared to geographically proximate whites. The lower rates of reporting an occupation among bison-reliant men are due to higher rates of reporting "other non-occupation responses" relative to native men who were not reliant on the bison, as well as whites. We report these results in Online Appendix Table **??**.

at the reservation-level. In some cases, we control for reservation-level characteristics, such as the ruggedness of reservation terrain and surrounding counties' economic characteristics, as well as more aggregate controls that vary at the level of the nation, including whether the society was historically nomadic, the proportion of their calories derived from agriculture, whether the society exhibited observable wealth distinctions, or whether the society had an aristocracy. Each of these controls are described in the table notes when they are used. Standard errors are clustered at the nation-level in all specifications.

Figure 3 displays means and 95% confidence bands for the average income of nations that were exposed to the bison's slaughter and those that were not bison-reliant. There are two important takeaways from this figure. First, between 1945 and 2019, nations that were exposed to the slaughter had systematically lower incomes than those that were never bison-reliant. Second, we do not observe any convergence in incomes over time, suggesting that nations that were exposed to the slaughter did not manage to successfully adjust to this economic shock throughout the twentieth century and into the present-day.

Table 4 pools observations from 1945-2019 together and displays estimates of the income difference for the whole time period. In these specifications, the dependent variable is the natural logarithm of income per capita, so that the coefficient estimate on "Exposed to Slaughter" is interpreted in log points. Column (1) provides the baseline estimate which only conditions on year fixed effects. The coefficient estimate in this column suggests that incomes in previously bison-reliant communities were approximately 25 percent lower than those in communities that were not bison-reliant through the latter half of the twentieth century and beginning of the twenty-first century. This translates to $3,100 in 2010 dollars which is large, given that mean per capita income on reservations was $11,781 annually.

The remaining columns in Table 4 provide evidence that the income difference is attributable to the slaughter itself, and not differences in pre-existing characteristics or other post-slaughter events like the Dust Bowl, differential application of the *Dawes Act*, or uptake of self-governance powers. In these columns, we interact each control with a linear time trend to allow income trajectories to differ based on the covariate or set of covariates we are evaluating.[24] Our baseline estimate is robust to accounting for differences in geographic factors (2), cultural factors (3),

[24]The results are also robust to interacting the controls with a full set of time dummies.

colonial factors (4), and for other major disruptive factors (5).[25]

In the first few decades of the twentieth century, many nations in the Great Plains were undergoing a coerced transition to agricultural production which could have been substantially undermined by the occurrence of the Dust Bowl. We evaluate the possibility that bison nations were disproportionately impacted by the Dust Bowl using data from Hornbeck (2012) on the percentage of land that was eroded during this episode. These values are available at the county-level, and we match county values to reservations by taking a weighted average of erosion according to the share of the area of each reservation that overlaps with each county. Although we know from the literature that the Dust Bowl had an important impact on the Great Plains, column (6) shows that this is not a viable explanation for the differential income trajectories of Native American communities that were exposed to the slaughter of the bison.

Beyond the unique case of the Dust Bowl, differences in agricultural productivity and the suitability of the land for agricultural production could have impacted economic development over the twentieth century. We examine this potential explanation in columns (7) and (8). Column (7) conditions on the logarithm of the value of crops and the logarithm of the value of livestock.[26] Column (8) includes measures of suitability for agricultural production. Here, we use the percent of a reservation that is classified as prime land and its square, as compiled by Leonard et al. (2020). Neither set of controls meaningfully reduces the estimate on the exposure to the slaughter.[27]

In column (9), we consider the possibility that there was differential application of the *General Allotment Act* of 1887, also known as the *Dawes Act*, one of the most well-documented fed-

[25]Geographic controls include the logarithm of the average ruggedness in a nation's homeland, the logarithm of the area of a nation's homeland, and the latitude of the homeland, which we view as a proxy for unobserved climatic factors that may differentially influence northern and southern nations. We do not include longitude, as we view it as a proxy for the timing of settlement, which we consider explicitly in column (4). Cultural factors include an indicator for whether the nation was historically nomadic, whether they had a history of wealth distinctions, and the settler population density in a nation's territory in 1500 and 1600, as well as dummies if a nation is missing any of these values. Colonial controls include whether nations without a shared history of governance were forced to coexist on reservations, if they were historically centralized, the year a railway first entered the nation's territory, indicators for the years that a nation's land was ceded, and settler population density in a nation's homeland in 1790 and 1870. Finally, disruption includes the number of battles in a nation's homeland in the pre-slaughter period and the distance a nation was displaced from their traditional homelands during the reservation era.

[26]Both of these measures are again constructed at the reservation level as a weighted average across all counties intersecting a reservation's land.

[27]This is despite the fact that there was substantial re-specialization of the bison nations into the raising of livestock (see, Online Appendix Figure **??**). Both the value of livestock and the number of cattle in the counties that contained bison reservations increased significantly after World War II.

eral policy interventions that directly influenced economic development on reservations. While this policy is complex, it effectively did three things to reservations: (1) it reduced their size; (2) created a "checkerboarding" of land titles (fee simple, individual trust, and tribal trust); and (3) created parcels of fractionated ownership.[28] If nations that were exposed to the slaughter received differential treatment under the *Dawes Act*, this could explain the persistently lower incomes among these nations today, given the impacts of fractionated ownership on economic development (Leonard et al., 2020). Our estimate of the treatment effect in column (9) shows that this is not the primary explanation for the income difference between bison nations and those that were not bison-reliant.

Finally, we consider differences in self-government status in column (10). Beginning in the 1930s, a number of important federal policies were implemented with the intention of reversing the assimilationist goals of the existing federal Indian policy. The first of such notable policies was the *Indian Reorganization Act* (IRA) of 1934, which curtailed future allotment under the *Dawes Act* and was intended to provide a path for nations to regain sovereignty over lands and assets.[29] Other policies that followed the IRA further strengthened nations' capacity for self-governance, including the *Indian Civil Rights Act* [1968] and the *Indian Self Determination and Education Assistance Act* (ISDEAA) [1975]. The ISDEAA, in particular, was an important piece of legislation for allowing greater Indigenous autonomy over the provision of programs and services, like education, health, law enforcement, and childcare. Column (10) conditions on an indicator that equals one if the nation had a constitution under the IRA, as well as an indicator that equals one if the nation had an Indian Health Services compact or a compact under Public Law 93-638, both of which reflect application of the ISDEAA. Again, this does not substantially diminish the persistent relationship between being exposed to the rapid slaughter and income.

We use several other strategies to evaluate the robustness of our results. First, we use an IV specification that leverages the cost of traveling between nations' ancestral homelands and cities that were historically important for the trade in bison robes. These results are located in Online Appendix Table **??**. The instruments in this exercise are only weakly correlated with treatment; however, the treatment effect remains economically and statistically significant. We

[28] Fractionated ownership is a form of entitlement where a parcel of land is owned by multiple individuals. The number of owners typically increases over time due to divided inheritance laws. Some parcels on reservations can have hundreds of owners with equal interest in the land.

[29] Frye and Parker (2021) argue that the IRA increased federal oversight and decreased economic growth.

also consider the possible effect of spatial autocorrelation in Online Appendix Table **??** (Kelly, 2020). Our results remain unchanged when we control for various sets of geographic factors, including state fixed effects and latitude and longitude and account for spatial lags in the error term and dependent variable. We accompany this with an estimate of the Wald statistic for spatial autocorrelation, which suggests limited evidence of spatial autocorrelation. Finally, for completeness, we display spatial standard errors estimated using the methodology of Conley (1999) which do not change the results.

Our results indicate that the persistently lower income among bison nations is not driven by differences in pre-slaughter characteristics or other experiences related colonization. Post-slaughter Federal Indian Policy, like the *Dawes Act* and the subsequent policies related to self-government also do not appear to have differentially impacted bison communities. Differences in land quality, and agricultural output are also unlikely explanations. Overall, it is clear that there is a robust relationship between exposure to the slaughter of the bison at the end of the nineteenth century and incomes per capita throughout the twentieth century and into the twenty-first century. Next, we shift our attention towards understanding the factors that have contributed to the persistence of this economic shock.

VI. Mechanisms of Persistence

When regions are exposed to large economic shocks, factors of production will typically adjust. Why then, have historically bison-reliant communities remained persistently disadvantaged into the present? We argue that the economic fallout from the bison's decline made previously bison-dense areas unattractive relative to other, similar locations, shifting the path of economic development among the formerly bison-reliant Indigenous communities. We provide evidence that historical access to credit influenced occupational re-specialization and migration which generated further consequences for future economic activity. Ultimately, the bison communities became trapped in a cycle where regional poverty deterred future economic development. We begin by showing how the loss of the bison altered the path of regional economic development for impacted communities. We then discuss more specific aspects of adjustment related to access to credit and the implications of limited credit for occupational re-specialization and migration. We conclude by showing that bison nations that had relatively easier access to credit were substantially more successful in adjusting to the economic shock over the century that followed.

That the decline of the bison made formerly bison-dense locations economically unattractive relative to locations that were not bison-reliant can be seen in patterns of population growth. Figure 4 shows how population evolved across each type of region from 1850 to 1970. Panel A displays these raw trends for the white population.[30] Panel B displays coefficient estimates from a regression of the white population on year×treatment interactions for all years between 1850 and 1970.[31] The next two panels display results from similar regressions for population density. Until 1890, bison-reliant regions had similar white populations and levels of population density as regions that were not bison-reliant. However, by the turn of the twentieth century, population trends in these regions diverged sharply, as would be expected if people continued to settle in areas with greater economic opportunity.[32]

Financial development also occurred more slowly in bison-reliant regions, compared to regions that were not bison-reliant. Figure 5 shows trends in the number of banks in counties that overlap reservations for bison nations and nations that were not bison-reliant.[33] While the financial sector during this time period included a broad set of institutions, commercial banks played a vital role for businesses, firms, and individuals, alike (Davis and Gallman, 1978), so we focus on their expansion in what follows. Because of the large expansion of the banking sector between 1940 and 1980, as well as the fact that no reliable bank data exist by county for the intermediary period, we split these figures by pre-1936 and post-1980 eras. The left panels display the raw trends and the right panels show statistical differences between bison regions and regions that were not bison-reliant by year. It is well known that Native Americans face challenges in accessing credit today (Jorgensen and Akee, 2017) and the data presented in Figure 5 show that, even within the Indigenous population, inequalities in access to credit are not a modern phenomenon. These patterns are clearly reflected in related outcomes in these regions today. For example, Native Americans who belong to nations that lost the bison during

[30]We compute estimates of the non-white population as an average of all counties that intersect with a reservation's geographic boundary, where we assign counties weights based on the inverse of their area that intersects with the reservation.

[31]Specifications include year dummies and do not include a constant. Standard errors are clustered by Indigenous nation.

[32]Similar patterns are apparent in non-white population trends which can be found in Figure ?? of the Online Appendix.

[33]The banking data come from three different sources: banks in 1870, 1880, and 1890 are from Jaremski and Fishback (2018), banks from 1920-1936 are from Hornbeck (2012), and those from 1980-2010 are from Haines et al. (2018).

the rapid slaughter are significantly less likely to be self-employed or to own their own homes in reservation areas.[34]

Access to credit has potential implications for both occupational re-specialization and inter-regional migration. Both forms of adjustment can be costly, making access to credit or other forms of liquidity important for income-constrained populations. If the absence of a formal financial sector prevented bison-reliant nations from adjusting to the loss of the bison over time, then we should see the consequences reflected in the data in terms of occupational choice, the ability to migrate, and future agglomeration. We would also expect bison-reliant nations with greater access to credit to have been better able to adjust. We examine each of these patterns in sequence.

At the start of the twentieth century much of the United States was well into a structural transformation away from a predominantly agricultural economy towards an industrial one. As noted by Gallman et al. (2020), this transformation was characterized by capital-deepening across all major industrial sectors. Davis and Gallman (1978) argue that financial intermediation played a key role during this period, which in turn affected the shape of the capital stock and, consequently, the types of industries across regions. During the same time period, bison-reliant nations were incentivized and explicitly pressured by the BIA to enter or remain in agriculture (Iverson, 1997; Ostler, 2001).[35] Thus, in light of the institutional pressures from the BIA, whether bison nations were able to take part in the economy-wide restructuring would have depended on their access to financial resources to facilitate this transition. However, as displayed in Figure 5, access to credit among nations that never relied on the bison diverged relative to the bison nations. Figure 6 provides evidence consistent with the notion that limited access to credit precluded bison nations from participating in the ongoing structural transformation of the economy with essentially equal levels of manufacturing before the slaughter and divergence

[34]Online Appendix Table **??** displays OLS estimates of the relationship between the bison's slaughter and each of these modern outcomes, conditional on income, using the five-year average 2010 and 2019 American Community Surveys.

[35]The BIA promoted agriculture among Indigenous nations, providing agricultural implements and seeds to support the transition into commercial farming (Ostler, 2001). BIA reports from the early twentieth century regularly mention the farming and irrigation improvements that they helped finance and operationalize. Many treaties explicitly express the BIA's desire for Native Americans to become self-sufficient farmers. As an example from the agreement with the Sisseton and Wahpeton Bands of Sioux Indians in 1872: "Whereas, said territory, now proposed to be ceded, is no longer available to said Indians for the purposes of the chase, and such value or consideration is essentially necessary in order to enable said bands interested therein to cultivate portions of said permanent reservations, and become wholly self-supporting by the cultivation of the soil and other pursuits of husbandry."

in manufacturing employment and capital invested afterwards.

We examine the implications of such limited access to credit for industrial adjustment in Table 5. The first column evaluates whether the probability that an individual reported working in an industry differed between bison-reliant men and men who were not bison-reliant between 1900 and 1930. Here, we see that there was notable convergence over time. Column (1) shows that bison nations were thirty percentage points less likely to report "having an industry" in 1900 relative to other native nations; by 1930, they were ten percentage points less likely to report "having an industry" relative to other native nations.[36] In column (2), we evaluate the probability of working in agriculture, an industry that required capital but which was often financed by the BIA. Column (3) evaluates the probability of working in a non-agricultural, capital-intensive industry (manufacturing, mining, and construction), which would have been more likely to have received financing from traditional means.[37] From columns (2) and (3), we can see that by 1930, there was complete convergence in the probability of working in occupations within the agricultural industry, but divergence in occupations in other capital-intensive industries. These estimates suggest that, as the rest of America benefited from the structural transformation away from agriculture and into industry, the economies of bison nations were increasingly likely to be grounded in low-wage agricultural production.

Did credit facilitate economic adjustment when it was accessible? The last three columns of Table 5 provide evidence that this was the case. In these regressions, we interact each treatment X year variable with the natural logarithm of the distance to the closest bank in 1870, which was the year that the rapid slaughter began.[38] Column (4) shows that the convergence in the probability of reporting an industry observed in column (1) was not dependent on early access to credit. Thus, in columns (5) and (6), we seek to determine whether, within the sample of individuals who reported having an industry, access to credit was related to the types of industries in which bison-reliant men worked. We find that, conditional on reporting some industry, bison-reliant men who were farther from a bank in 1870 were more likely to find

[36]These specifications include year fixed effects and do not include the slaughter indicator, so the coefficients on each "Exposed to Slaughter$\times$ Year" interaction should be interpreted as the difference in outcome between bison-reliant and non-bison reliant nations in the specified year of interest.

[37]Our classification of "capital-intensive" industries largely follows that of Gallman et al. (2020) who classify manufacturing, mining, and hand-trades as capital-intensive.

[38]We compute the distance to the closest bank in 1870 by taking the "as the crow flies" distance between the centroid of the reservation and the closest county centroid with a bank. We use this distance metric because most counties that contained reservations did not have banks in 1870.

themselves in agriculture and less likely to find themselves in other capital-intensive industries by 1930. These estimates are conditional on the natural logarithm of the distance to the closest metropolitan area, so that the comparison is between equally isolated locations with varying proximity to credit. This is evidence that the agriculture-related capital and financial resources supplied by the BIA acted as a substitute for traditional forms of credit, and that access to traditional forms of credit had implications for the types of industries in an area.

Other evidence that bison nations were in need of liquid assets at the turn of the twentieth century is found in the BIA annual reports from 1915-1920. These reports include nation-level income and wealth for a small subset of nations (52 in total).[39] Online Appendix Table **??** reports the proportion of per capita income from various sources by former bison reliance. Formerly bison-reliant nations were more likely to obtain income from selling and leasing land, selling livestock, and from rations provided by the US government. They were less likely to have income from "native industries" which would have included traditional harvesting activities or art sales, as well as from employment wages. Overall, these statistics indicate that bison-reliant nations responded to the slaughter by selling or leasing capital assets to help maintain incomes during the first few decades after the slaughter.

If a lack of access to credit prevented bison nations from adjusting to this shock over time, then we would expect other margins of adjustment that require financial resources, like migration to be affected. Data on out-migration does not exist at the reservation level during this time period. We can, however, understand what was occurring at the county-level. Figure 7 shows net-in-migration rates between 1940 and 2000. We plot these separately for counties that overlap with a reservation containing members of a bison nations and those that overlap with reservations that were not bison-reliant.[40] There are at least two notable results in Figure 7. First, neither bison nations nor those that were not bison-reliant experienced net out-migration, as would be depicted by a negative value on the vertical axis. Second, in some years, there was net in-migration and this in-migration was systematically larger for regions that were not bison-reliant.

[39] It is important to note that these records include income from sources that did not necessarily reach individuals; non-trivial amounts of money were held in trust by the federal government and treaty annuities and rations were frequently reported to have been misused or not delivered (Campbell, 2012; Germain, 2009; Göcke, 2012; Goldstein, 2014; Prucha, 2014).

[40] Due to the limited availability of race-based data prior to the 1970s, the first three decades use information on non-white people and the last three decades use information on Native Americans, specifically.

It is important to view these trends in consideration of the fact that migration was restricted to varying degrees during the first half of the twentieth century. Geographic mobility was explicitly restricted until 1924 when the Indian Citizenship Act granted free movement to those born after 1924. By the 1950s, relocation away from reservations was actively encouraged through the Indian Relocation Act of 1954. Thus, the lack of out-migration from the 1950s to 1970s in Figure 7 may be somewhat surprising. However, there is evidence that Native Americans who ended up moving to urban centers as a result of the relocation policy experienced additional hardships and often returned to their reservations (Walls and Whitbeck, 2012). Further, even though Figure 7 shows that, on average, there was not net out-migration among bison nations, it does not rule out the possibility of selective out-migration. As suggestive evidence that selective out-migration was not occurring, we show in Online Appendix Figure **??** that the average rates of educational attainment for bison regions and regions that were not bison-reliant were roughly equivalent between 1940 and 1990. In Online Appendix Figures **??** and **??**, we also show that the proportion of non-white people who were of working age was similar for bison-reliant regions and those that were not bison-reliant. This suggests there was not differential net-migration during prime working ages.

Table 6 provides more direct evidence of a lack of selective out-migration for the 2010 to 2019 period. The first column shows that members of bison nations have lower attainment of Bachelor's degrees, but that proportionately more of them live on Native homelands, suggesting a greater retention of highly educated people. The next two columns show that bison-reliant individuals who live on Native homelands are not more likely to live in the same house as one year ago, nor more likely to move across state lines, in comparison to bison nations who live outside of Native homelands, as well as in comparison to other Native nations. Finally, column (4) shows that, of those who ever had an occupation, bison nations on Native homelands are not more likely to report having no work in the last 5 years compared to bison nations outside of Native homelands. Again, this suggests that positive selective out-migration is not confounding our results.

We evaluate whether out-migration increased in bison communities, relative to communities that were not bison-reliant when there was greater access to credit in Table 7. We focus on migration from 1980-1990 and 1990-2000 for two reasons. First, earlier migration rates are available for the "non-white" population only, whereas migration rates can be measured for American Indians after 1980. Second, part of this table evaluates how banks in one decade affect migration rates in the following decade and the post-Depression banking data only begin in 1980. All estimates are conditional on the natural logarithm of the distance to the closest metropolitan statistical area. This ensures that we are comparing reservations that are equally isolated but that have different access to banking. Column (1) shows that bison-reliant counties with more banks in 1980 saw greater net-in-migration than bison counties with fewer banks. This likely reflects the fact that greater access to finance helped attract and retain people in these areas. Column (2) shows that replacing the number of banks in 1980 with the distance to a bank in 1870 leads to the opposite result: places that were farther from banks in 1870 experienced less net-in-migration between 1980 and 1990. While we cannot disentangle whether this was because of greater out-migration or less in-migration, it is supportive of the hypothesis that limited historical access to credit was a push factor and that greater contemporaneous access to credit was a pull factor for communities once migration restrictions were lifted. Columns (3) and (4) mirror these findings for migration between 1990 and 2000.[41]

Thus far, we have shown that greater historical access to credit facilitated the adjustment to the economic shock through occupational re-specialization and migration. In Table 8, we evaluate whether this early access to credit mitigated the impacts of the bison's decline on income per capita into the present day. Since banks were likely to appear in more densely populated regions, some specifications in this table evaluate whether differences in historic population density are related to contemporary differences in income. Column (1) replicates the main result for the 1980-2019 sample. The next columns interact treatment with the log distance to the closest bank in 1870 (2), the log of population density in 1870 (3), and both of these interactions simultaneously (4).

In Column (2) of Table 8, the coefficient estimate on distance to a bank in 1870 interacted with treatment is negative and statistically significant indicating that bison nations that were farther from historical banks suffered substantially more from the loss of the bison into the twenty-first century. Column (3) shows that, over time, bison communities that were located in more densely populated regions historically were no better-off than bison communities that

[41]For summary statistics on income, migration, population density, and our banking measures, see Online Appendix Table **??**.

were less dense. Though the standard errors are relatively large in Column (4), the fact that the point estimate on treatment X ln(Dist Bank 1870) changes little from Column (2) suggests that historical access to banks is important for contemporary income independent from historical population density.

Nations that were exposed to the slaughter also have fewer banks and lower population densities today. These estimates are found in columns (1) and (2) of Table 9 for data from 1989-2019, where column (3) replicates the income results for this same time period. Once again, we see that the relationships between exposure to the slaughter and these contemporary outcomes are weaker for bison communities that were closer to historical banks, as shown in columns (4), (5), and (6). The estimates of exposure to the slaughter in the banking and population density specifications are statistically less precise than those where income is the dependent variable, but support the conclusion that historical access to financial institutions has implications for economic recovery over a long horizon.

As a final illustration of the importance of historical access to credit for economic recovery, we consider whether there is the potential for shocks to amplify one another. Specifically, we ask whether areas that experienced more bank failures during the Great Depression suffered more from the loss of the bison. This exercise is an alternative way of testing whether access to credit matters for the recovery from economic shocks. The difference between this exercise and the previous one is that here we examine whether the removal of credit amplifies the shock, rather than examining whether access to credit mitigates the shock. Columns (7)-(9) of Table 9 report estimates from models that interact the number of bank failures between 1929-1936 with an indicator for exposure to the bison's slaughter.[42] Consistently, bison nations that experienced more bank failures have worse economic outcomes, even compared to other bison nations. These results show how economic shocks can amplify one another, making recovery from one event more difficult when a region is faced with a secondary shock. They also provide evidence that further supports the role of access to credit as a potential contributing factor to the persistent effects of the bison's decline.

The loss of the bison was an enormous economic shock to the communities that had once

[42] As a proxy for bank failures, we use the difference in the number of banks in 1929 and 1936. We acknowledge the potential endogeneity concerns with using bank failures and, thus, these results should be interpreted with this qualification in mind.

relied on it and it is clear that limited early access to financial institutions, coupled with the federal government's policy towards Native Americans through the nineteenth, twentieth, and twenty-first centuries ultimately prevented the formerly bison-reliant nations from adjusting to this shock over time. While the results of this section are informative for understanding the role of credit in facilitating adjustment over a long horizon, they are also cautionary. Today, Native Americans disproportionately live in credit deserts, with some communities still 50-70 miles from the nearest bank (Ahtone, 2018). Until credit is more accessible, our analysis foreshadows the likely economic trajectory for Indigenous or other undercapitalized communities who are impacted by economic shocks, like climate change, structural change, or other unforeseen circumstances.

VII. Conclusion

At the beginning of the nineteenth century, the North American bison roamed the Great Plains in the tens of millions, but by 1880, the bison were nearly extinct, the result of a mass slaughter that occurred within as little as 10 years. This is the first paper to empirically quantify the persistent effects of the slaughter on the Native American nations who relied on the bison for over 10,000 years prior to its extinction. We compile historical, anthropological, geographic, and modern economic data to show that the elimination of the bison affected the well-being of the Indigenous peoples who relied on them, both immediately after the bison's decline, and up to 150 years later. We argue that the loss of the bison resulted in a reversal of fortunes: historically, bison-reliant societies were among the most well-off people on the continent, but today, they are among the poorest.

We study the dynamic path of development through which this shock has persisted into the present day and demonstrate that early access to credit could have mitigated the persistent effects of the loss of the bison. While the loss of the bison was a unique historical event, large regional economic shocks are not. Similarly, Native Americans occupy a unique institutional space in the United States but barriers to adjustment, like costly migration, low levels of development, and credit constraints are common. The experiences of the formerly bison-reliant peoples, important in their own right, also shed light on how economic shocks can persist for decades in the absence of access to other financial resources.

Data availability statement: The data and code underlying this research are available on Zenodo at `https://doi.org/10.5281/zenodo.7838530`

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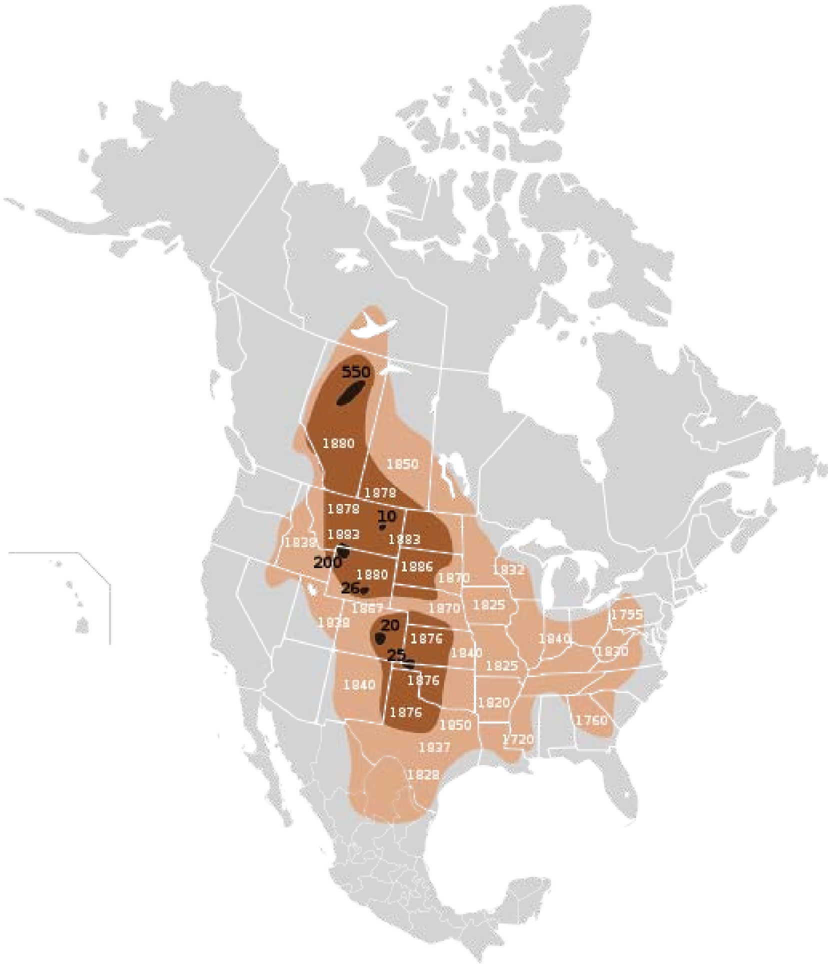
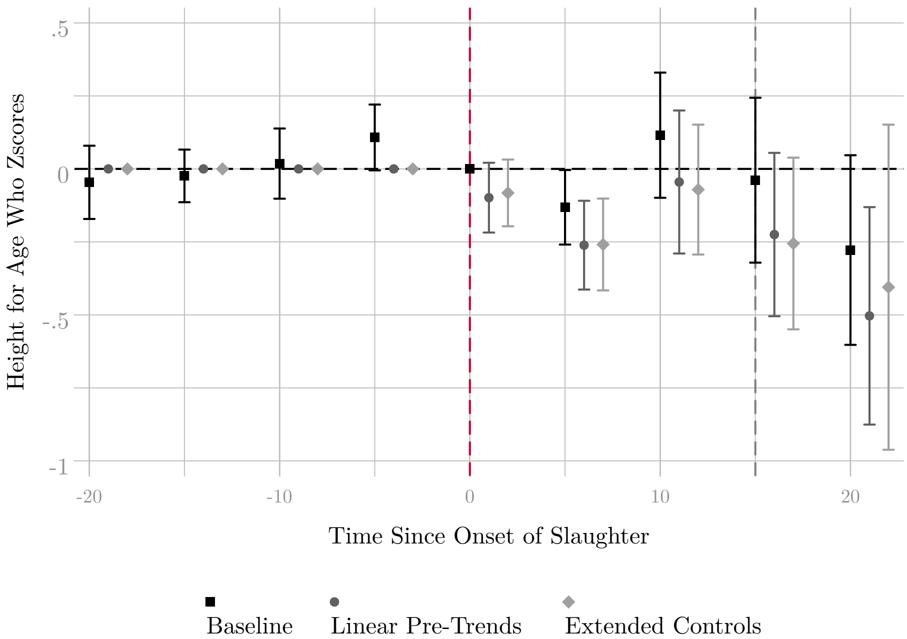
Figures

Figure 1: The North American Bison's Range in 1730, 1870, and 1889



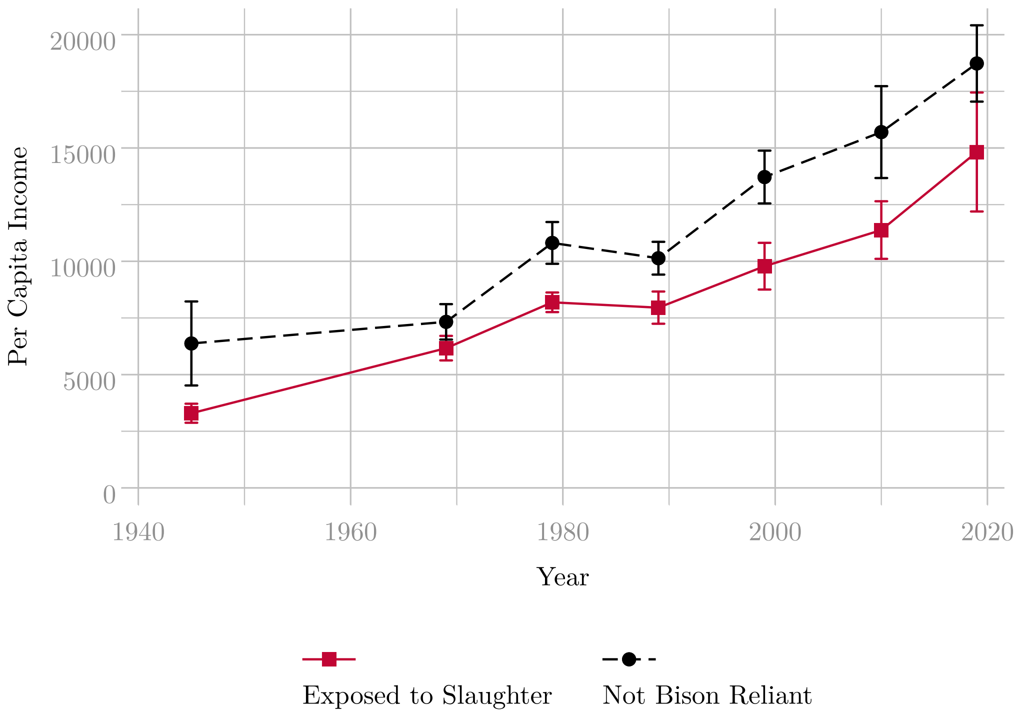
Notes: This is a digitized version of the map generated by Hornaday (1889) illustrating the range of the North American bison and the timing of its decline. The lightest brown region is the range as of 1730, the middle region is the range as of 1870, and the final black regions are the remaining herds (with labelled sizes) as of 1889. The 1889 herds were found in ranched captivity.

Figure 2: Event Study Coefficient Estimates of the Effect of the Bison's Slaughter on Height-for-Age Z-Scores



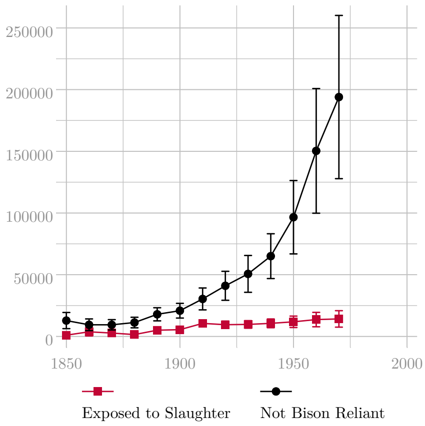
Notes: This figure plots coefficient estimates from event study specifications where the dependent variable is the 2006 World Health Organization's height-for-age Z-score. Coefficient estimates are presented for five-year birth cohorts with 90% confidence intervals. The dashed red line indicates the start of the slaughter (1871) and the gray dashed line indicates the end of feasible bison reliance (1886). All specifications include Indigenous nation, age, and five-year cohort fixed effects, as well as an indicator for perceived lack of white ancestors. Coefficient estimates from the "linear pre-trends" model condition on a linear trend for the pre-1871 cohorts. Estimates from the "extended trends" model condition on colonial, cultural and geographic controls described in the main text. The date of birth in these specifications is restricted to be after 1850. The main data source is Franz Boas' 1889 to 1903 sample of Native American stature.

Figure 3: Real Per Capita Incomes by Exposure to the Rapid Slaughter

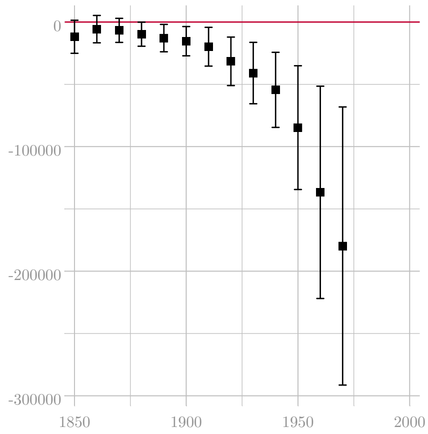


Notes: This figure shows trends in real per capita income for nations that were exposed to the slaughter and those that were not bison-reliant. Means and 95% confidence intervals are presented at the reservation-level and only include Native Americans living within reservation boundaries. All means are presented in 2010 dollars. The data for this figure were compiled by Leonard et al. (2020) and come from Indian Affairs Reports in 1945, the 1970, 1980, 1990, and 2000 decadal U.S. Censuses, and the 2007-2012 and 2015-2019 American Community Surveys.

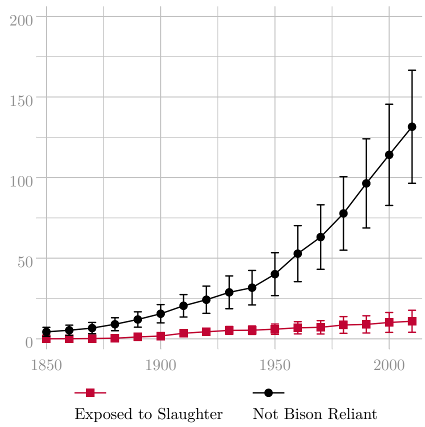
Figure 4: White Population and Population Density by Exposure to the Rapid Slaughter



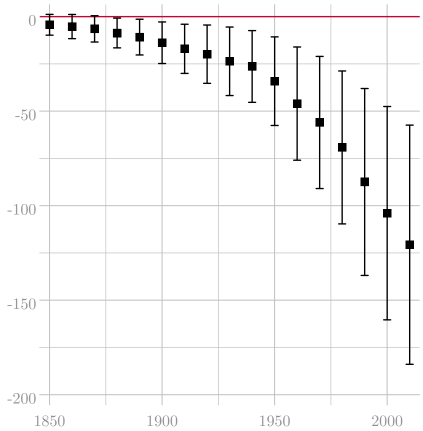
(a) White Population



(b) White Population



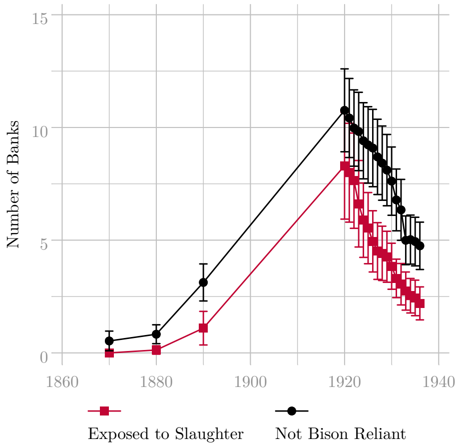
(c) Population Density



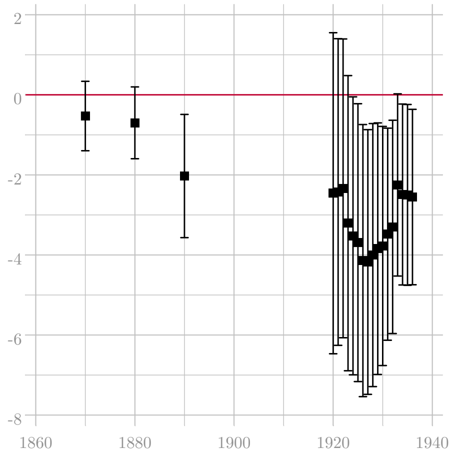
(d) Population Density

Notes: This figure shows trends in the white population and population density for nations that were exposed to the slaughter and those that were not bison-reliant. Each outcome is constructed as an average of all counties that overlap with a reservation's boundary, weighted by the area of the overlap. The left panels show means and 95% confidence intervals for each group. The right panels show coefficient estimates from a regression of the outcome on the interaction of exposure to the rapid slaughter and year, conditional on year fixed effects, so that the coefficient estimates can be interpreted as the average differences between the two groups in a given year. The population data for this figure come from the ICPSR Historical, Demographic, Economic, and Social Data: The United States, 1790-2002, and population density comes from Bazzi et al. (2020).

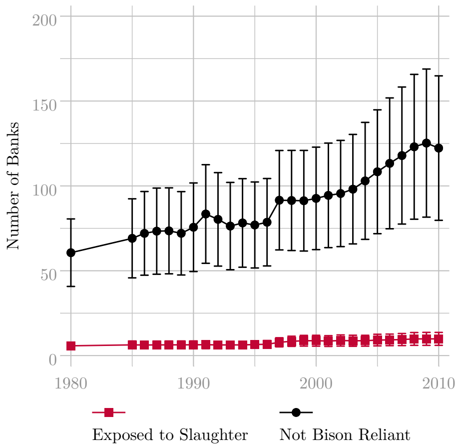
Figure 5: The Number of Banks by Exposure to the Rapid Slaughter



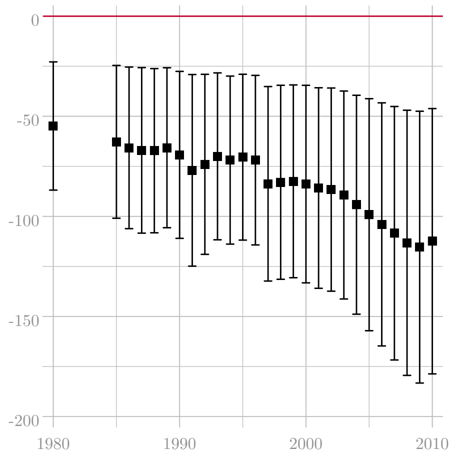
(a) Number of Banks, Pre-Depression



(b) Number of Banks, Pre-Depression



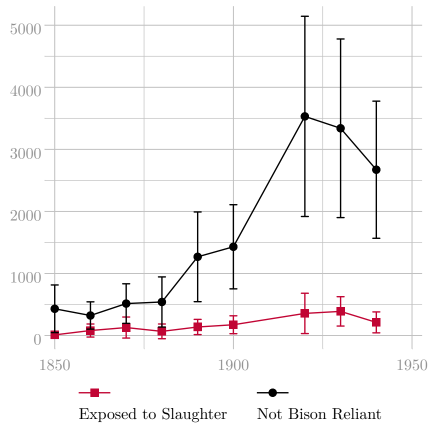
(c) Number of Banks, Post-Depression



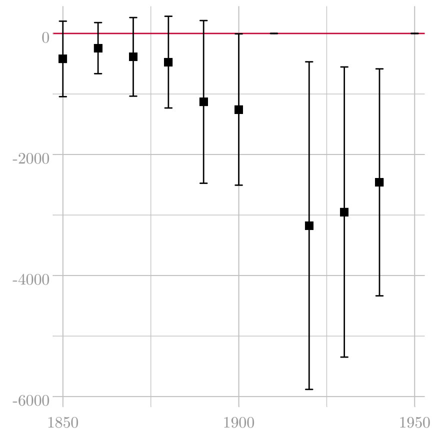
(d) Number of Banks, Post-Depression

Notes: This figure shows trends in the number of banks for nations that were exposed to the slaughter and those that were not bison-reliant. Each outcome was constructed as an average of all counties that overlap with a reservation's boundary, weighted by the area of the overlap. The left panels show means and 95% confidence intervals for each group. The right panels show coefficient estimates from a regression of the outcome on the interaction of exposure to the rapid slaughter and year, conditional on year fixed effects, so that the coefficient estimates can be interpreted as the average differences between the two groups in a given year. Outcomes for 1870 and 1890 are from the number of commercial banks Jaremski and Fishback (2018), supplemented with additional counts from the banker directories of the period. The banking data from 1920-1935 are from Hornbeck (2012) and data from 1980-2010 are from Haines et al. (2018).

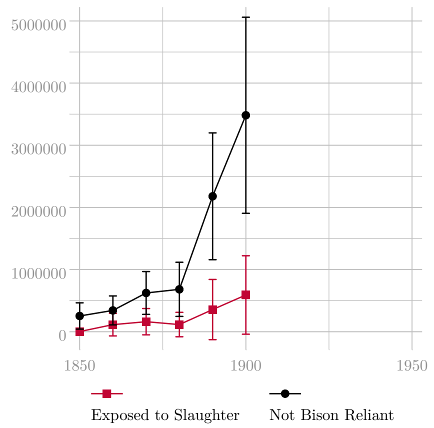
Figure 6: Manufacturing Establishments and Capital Invested in Manufacturing by Exposure to the Rapid Slaughter



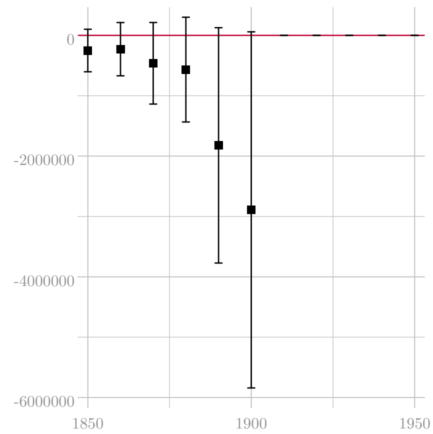
(a) Employment



(b) Employment



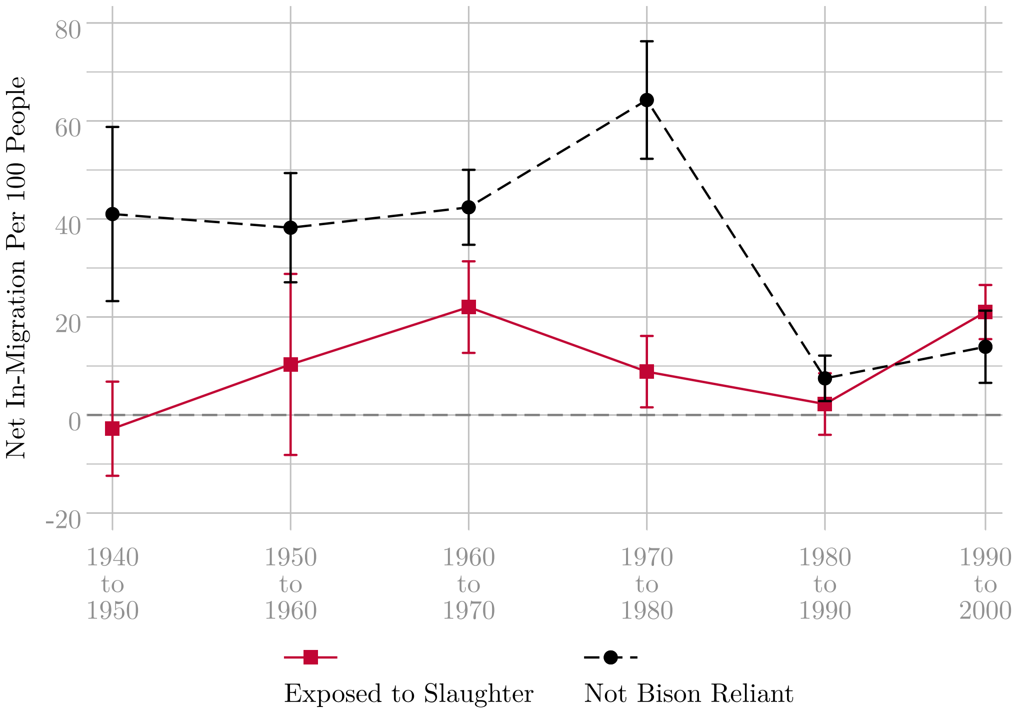
(c) Capital Invested



(d) Capital Invested

Notes: This figure shows trends in employment and capital investment in manufacturing for nations that were exposed to the slaughter and those that were not bison-reliant. Each outcome was constructed as an average of all counties that overlap with a reservation's boundary, weighted by the area of the overlap. The left panels show means and 95% confidence intervals for each group. The right panels show coefficient estimates from a regression of the outcome on the interaction of exposure to the rapid slaughter and year, conditional on year fixed effects, so that the coefficient estimates can be interpreted as the average differences between the two groups in a given year. Data are from the ICPSR Historical, Demographic, Economic, and Social Data: The United States, 1790-2002.

Figure 7: Net In-Migration by Exposure to the Rapid Slaughter



Notes: This figure shows trends in net in-migration for nations that were exposed to the slaughter and those that were not bison-reliant. The figure depicts means and 95% confidence intervals. The underlying values were constructed as an average of all counties that overlap with a reservation's boundary, weighted by the area of the overlap. Estimates for 1940-1960 are for the non-white population and estimates for 1970-1990 are for the Native American population. As an example, net in-migration between 1960 and 1950 is $\text{pop}_{1960} - \text{pop}_{1950} - \sum_{t=1950}^{1959} \text{births}_t + \sum_{t=1950}^{1959} \text{deaths}_t$. Net in-migration was constructed from: (i) deaths from the Multiple Cause-of-Death Mortality Data from the National Vital Statistics System of the National Center for Health Statistics from the NBER data site; (ii) births from the National Vital Statistics System of the National Center for Health Statistics; and (iii) population from the NHGIS county-level files.

Tables

Table 1: Summary Statistics for Pre-1900 Outcomes and Controls by Exposure to the Rapid Slaughter

	Exposed to Slaughter (1)	Not Bison-Reliant (2)	Difference (3)
Panel A: Nation Level Characteristics			
EA Fully/Partly nomadic	0.609	0.245	-0.363**
	(0.499)	(0.432)	
EA Historic Centralization	0.565	0.500	-0.065
	(0.507)	(0.502)	
EA Wealth Differences	0.130	0.340	0.209*
	(0.344)	(0.476)	
Log Population as of 1500	6.111	5.005	-1.105*
	(1.645)	(2.615)	
Log Ruggedness	2.756	3.331	0.575*
	(0.885)	(1.105)	
Observations	23	106	129
Panel B: Franz Boas Data			
Standing Height (CM)	156.58	150.56	-6.02***
	(18.24)	(20.64)	
Male Standing Height (CM) pre-slaughter	171.25	168.62	-2.63***
	(6.42)	(6.56)	
Female Standing Height (CM) pre-slaughter	158.82	155.95	-2.87***
	(5.35)	(5.57)	
Female	0.34	0.41	0.07***
	(0.47)	(0.49)	
Observations	2753	6238	8991
Panel C: IPUMS 1900 Historical Over-samples - Women			
% of Children Surviving	0.76	0.83	0.07***
	(0.25)	(0.22)	
Children ever born	4.93	4.68	-0.25**
	(2.61)	(2.47)	
Observations	1366	2412	3778
Panel D: IPUMS 1900 Historical Over-samples – Men			
Std Occupational Score	0.03	0.49	0.45***
	(0.75)	(0.64)	
Has an Occupation	0.52	0.87	0.35***
	(0.40)	(0.33)	
In Agriculture	0.42	0.59	0.17***
	(0.49)	(0.49)	
Observations	2439	4411	6850

Notes: This table displays sample means with standard deviations below in parentheses for nations that were exposed to the slaughter and those that were not bison-reliant. Panel A presents summary statistics at the nation level, Panel B presents statistics at the individual level for the Boas sample, and Panel's C and D present statistics at the individual level for the 1900 Census Over-sample for women and men, respectively. Column (1) reports summary statistics for nations who were exposed to the rapid slaughter and column (2) reports them for nations who were not bison-reliant. Column (3) reports difference-in-means tests between column (1) and (2). See Section III and Online Appendix Section **??** for more information, including data sources and variable construction. Additional summary statistics can be found in Table **??** and **??** of the Online Appendix. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: The Effect of the Bison's Slaughter on Height

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Height in Centimeters						
Exposed to Slaughter × Post-1886	-2.883***	-2.623***	-1.937**	-1.924**	-1.836*	-1.931**
	(0.738)	(0.620)	(0.811)	(0.850)	(0.950)	(0.758)
Adjusted R^2	0.882	0.884	0.839	0.839	0.880	0.900
Panel B: Height-for-Age Z-Scores						
Exposed to Slaughter × Post-1886	-0.315**	-0.274**	-0.242	-0.295**	-0.239	-0.324**
	(0.151)	(0.118)	(0.161)	(0.142)	(0.197)	(0.163)
Adjusted R^2	0.170	0.178	0.152	0.158	0.174	0.220
Individual Controls	X	X	X	X	X	X
Cohort-Nation Varying		X		X	X	X
Between Age 5-20			X	X		
Only Men					X	
Only Women						X
Observations	8991	8991	4566	4566	3491	5500
# Clusters	104	104	96	96	98	98

Notes: This table displays coefficient estimates from a difference-in-differences specification (Equation 1). In Panel A, the dependent variable is standing height in centimeters. In Panel B, the dependent variable is the World Health Organization's height-for-age Z-scores. All columns include fixed effects for Indigenous nation, age, 5-year birth cohorts, and survey year. The sample is restricted to those born after 1850. Individual controls include sex, perceived degree of white blood, whether an individual was born after the first railway entered their homeland, if they were born after the first land cession in their homeland, the settler population density in their homeland the decade they were born, and whether they were born after a major with the United States. Cohort-nation varying controls include cohort interactions with characteristics of their homeland territory including log of ruggedness, centroid latitude, log population density in 1500, and its square kilometers, as well as whether their society was traditionally nomadic, historically centralized, and whether it had wealth distinctions. See Sections III and IV and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: The Relationship Between the Bison's Slaughter and Child Mortality, Fertility, Maternal Deprivation, and Male Occupations in 1900

Panel A: Women and Children's Outcomes

	Prop. Children Surviving		Children Ever Born		Female	
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed to Slaughter	-0.104***	-0.155***	0.00572	0.00697	0.0647*	0.0911*
	(0.035)	(0.040)	(0.125)	(0.080)	(0.037)	(0.052)
Fertile during slaughter	X		X			
Born After 1871		X		X	X	
Born After 1886						X
Observations	3778	1713	11658	9273	19632	12489
Adjusted R^2	0.122	0.094	0.593	0.518		
# Clusters	87	77	95	94	100	94

Panel B: Men's Labour Market Outcomes

	Occ Score		Has Occ		Occ Score | Some Occ	
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed to Slaughter	-0.273***	-0.240***	-0.193***	-0.186***	-0.0421	-0.0507
	(0.084)	(0.086)	(0.062)	(0.062)	(0.057)	(0.065)
Born After 1871		X		X		X
Observations	6850	2456	6850	2456	5128	1737
Adjusted R^2	0.162	0.188	0.234	0.254	0.056	0.091
# Clusters	97	87	97	87	97	86

Notes: This table displays coefficient estimates from OLS specifications. Panel A presents estimates for women. The dependent variable in column (1) and (2) is the proportion of children born who survive and the sample only includes women who had at least one child. In column (3) and (4) the dependent variable is the number of children ever born and in column (5) and (6) it is a dummy variable that equals one if a respondent is female and born after 1871 and 1881 respectively. Panel B presents estimates for men between the ages of 20 and 65. The dependent variable in column (1) and (2) is the standardized occupational score. In column (3) and (4) it is an indicator that equals one if the individual reported having an occupation on the census. In column (5) and (6) it is the standardized occupational score, conditional on reporting an occupation. All specifications control for a quadratic in age, the logarithm of average ruggedness in a nation's homeland, the logarithm of the area of a nation's homeland, the latitude of the homeland, whether the nation was historically nomadic, whether they had wealth distinctions, population density in a nation's homeland in 1500 and 1600 and the interaction of all these variables with birth year. They also all include controls for whether a respondent was born after or during the year a railway first entered the nation's homeland, whether they were born after their land was ceded, settler population density in their nation's homeland at the time of their birth, and whether they were born after or during a major war with the United States, and year and census region fixed effects. Missing control values are dummied out. See Sections III and IV and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: The Relationship Between the Bison's Slaughter and Income Per Capita, 1945-2019

	(1) Baseline	(2) Geog	(3) Culture	(4) Colonial	(5) Disruption
Exposed to Slaughter	-0.247***	-0.202***	-0.245***	-0.168*	-0.195***
	(0.064)	(0.050)	(0.069)	(0.094)	(0.071)
Adjusted R^2	0.559	0.589	0.585	0.608	0.562
	(6) Dust Bowl	(7) Farming	(8) Prime Land	(9) Dawes Act	(10) Self Governance
Exposed to Slaughter	-0.246***	-0.251***	-0.243***	-0.241***	-0.225***
	(0.064)	(0.069)	(0.058)	(0.070)	(0.063)
Adjusted R^2	0.558	0.569	0.573	0.567	0.614
Observations	629	629	629	629	629
# of Clusters	61	61	61	61	61

Notes: This table displays coefficient estimates from OLS specifications. The dependent variable in all columns is the natural logarithm of income per capita for Native Americans living within reservation boundaries. All columns include year dummies. Column (1) displays baseline estimates. The remaining columns evaluate the robustness of the baseline estimate to a variety of alternative explanations. Each column includes a control, or set of controls, and their interactions with a linear trend. Column (2) controls for the logarithm of average ruggedness in a nation's homeland, the logarithm of the area of a nation's homeland, and the latitude of the homeland; column (3) controls for whether the nation was historically nomadic, whether they had wealth distinctions, population density in a nation's homeland in 1500 and 1600, and dummies for missing values; column (4) controls for forced coexistence, historical centralization, the year a railway first entered the nation's homeland, indicators for the years that a nation's land was ceded, and population density in 1790 and 1870; column (5) controls for the number of pre-slaughter battles the nation was involved in and the distance the nation was displaced from their traditional homeland; column (6) controls for whether the nation was allotted during the Dawe's Era, whether this variable is missing, and the percent of fractionated land on reservation; column (7) controls for whether the nation was impacted by the *Indian Reorganization Act*, signed a self governance agreement, and a dummy for whether this information is missing; column (8) controls for the fraction of land in the reservation's surrounding counties that experienced medium and high erosion during the dust bowl; column (9) controls for the reservation's surrounding county's logarithm of the value of animal products, the logarithm of the value of crops, and dummies for whether these values are missing; column (10) controls for the percent of the reservation that is prime land and its square. See Sections III and V and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: The Relationship Between the Bison's Slaughter and the Industrial Composition of the Workforce in 1900, 1910, and 1930 by Access to Banks in 1870

	Has Industry	Agriculture	Capital-Intensive	Has Industry	Agriculture	Capital-Intensive
	(1)	(2)	(3)	(4)	(5)	(6)
Exposed to Slaughter X Year=1900	-0.302***	-0.225***	-0.0308**	-0.397	-0.215	0.0153
	(0.065)	(0.069)	(0.014)	(0.571)	(0.264)	(0.095)
Exposed to Slaughter X Year=1910	-0.178***	-0.178***	-0.0373	-0.487*	-0.488***	-0.113*
	(0.053)	(0.059)	(0.031)	(0.265)	(0.136)	(0.067)
Exposed to Slaughter X Year=1930	-0.101*	-0.0182	-0.108***	0.0566	-0.518**	0.703***
	(0.058)	(0.075)	(0.037)	(0.354)	(0.228)	(0.220)
Exposed X Year=1900 X ln(Dist Bank 1870)				0.00755	0.0193	-0.00370
				(0.047)	(0.020)	(0.007)
Exposed X Year=1910X ln(Dist Bank 1870)				0.0250	0.0339**	0.00629
				(0.021)	(0.013)	(0.007)
Exposed X Year=1930 X ln(Dist Bank 1870)				-0.0123	0.0468**	-0.0655***
				(0.030)	(0.020)	(0.020)
Ln(Dist Bank 1870)				-0.0000382	-0.0116	0.00357
				(0.004)	(0.011)	(0.007)
Conditional on Having an Industry					X	X
Observations	15883	15883	15883	15883	11932	11932
Adjusted R^2	0.120	0.090	0.112	0.121	0.117	0.124
# Clusters	101	101	101	101	98	98

Notes: This table displays coefficient estimates from OLS specifications. The sample is restricted to be men between the ages of 20 and 65. The dependent variable in columns (1) and (4) is an indicator that equals one if the individual reports an industry of employment in the Census. The dependent variable in columns (2) and (5) is an indicator that equals one if the individual's reported industry is agriculture. In columns (3) and (6), it is an indicator that equals one if the individual reported working in another capital-intensive industry, which includes manufacturing, mining, and construction. All specifications include year, census region, and year X census region fixed effects, as well as a quadratic in age. See Sections III and VI and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: The Relationship Between the Bison's Slaughter and Indicators of Selective Out-Migration in 2010 and 2019 by Homeland Status

	BA or More	Same House	Moved States	No Work Past 5-years
	(1)	(2)	(3)	(4)
Exposed to Slaughter	-0.0429***	-0.0175	-0.00659	0.0444**
	(0.013)	(0.017)	(0.008)	(0.016)
	[0.061]	[0.587]	[0.587]	[0.032]
Exposed to Slaughter X Homeland	0.0359***	-0.00685	-0.00100	-0.0352
	(0.010)	(0.017)	(0.005)	(0.023)
	[0.079]	[0.759]	[0.890]	[0.315]
In Homeland PUMA	-0.0717***	0.104***	0.0185**	0.0905***
	(0.010)	(0.019)	(0.007)	(0.030)
Observations	67871	67871	67871	67871
Adjusted R^2	0.038	0.055	0.016	0.063
# Clusters	21	21	21	21

Notes: This table displays coefficient estimates from OLS specifications. The dependent variable in column (1) is an indicator that equals one if the individual has a BA or higher. In column (2), it is an indicator that equals one if the individual reported living in the same house as the previous year. In column (3), it is an indicator that equals one if the individual reported that they moved states in the last five years. In the final column it is an indicator that equals one if the individual reported having no work in the past five years. All specifications include a year dummy for 2010, state fixed effects, a sex indicator, and a quadratic in age. See Sections III and VI and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses and wild cluster bootstrap p-values are in brackets. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: The Relationship Between the Bison's Slaughter and Net In-Migration Rates by Access to Banks in 1870

	Migration, 1980-1990		Migration, 1990-2000	
	(1)	(2)	(3)	(4)
Exposed to Slaughter	-10.63*	200.9***	-0.316	13.76
	(5.372)	(69.255)	(6.891)	(69.617)
Exposed × Ln(# Banks 1980)	23.49***			
	(5.816)			
Exposed × Ln(Dist Bank 1870)		-16.38***		-0.537
		(5.359)		(5.477)
Exposed × Ln(# Banks 1990)			11.38**	
			(4.793)	
Observations	119	119	119	119
Adjusted R^2	0.023	0.007	-0.014	-0.026
# Clusters	61	61	61	61

Notes: This table displays coefficient estimates from OLS specifications. The dependent variable in columns (1) and (2) is the net in-migration rate of Native Americans (per 100 people) between 1980 and 1990. In columns (3) and (4), it is the net in-migration rate of Native Americans between 1990 and 2000. Column (1) conditions on the natural logarithm of the number of banks in 1980 (point estimate -7.324**) and column (2) conditions on the natural logarithm of the distance to the closest bank in 1870 (point estimate 0.251). Column (3) conditions on the natural logarithm of the number of banks in 1990 (point estimate -3.202) and column (4) conditions on the natural logarithm of the distance to the closest bank in 1870 (point estimate 0.0739). As an example, net in-migration between 1980 and 1990 is $\text{pop}_{1990} - \text{pop}_{1980} - \sum_{t=1980}^{1989} \text{births}_t + \sum_{t=1980}^{1989} \text{deaths}_t$. All estimates are conditional on the natural logarithm of the distance to the closest metropolitan statistical area. See Sections III and VI and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: The Relationship Between the Bison's Slaughter and Income from 1989-2019 by Access to Banks and Population Density

	(1)	(2)	(3)	(4)
Exposed to Slaughter	-0.2599***	1.7245	-0.1463	1.1981
	(0.0719)	(1.1179)	(0.1306)	(1.1456)
Exposed × Dist Bank 1870		-0.1545*		-0.1082
		(0.0873)		(0.0930)
Exposed × Pop Dens 1870			0.01509	0.007838
			(0.0309)	(0.0302)
Ln(Dist Bank 1870)		-0.0295***		-0.0270***
		(0.0064)		(0.0076)
Ln(Pop Density 1870)			0.0363**	0.00868
			(0.0140)	(0.0128)
Observations	405	405	405	405
Adjusted R^2	0.321	0.348	0.357	0.364
# Clusters	61	61	61	61

Notes: This table displays coefficient estimates from OLS specifications. The dependent variable in all columns is the natural logarithm of income per capita among Native Americans living within reservation boundaries. All columns include year fixed effects, a control for the natural logarithm of the distance to the closest metropolitan statistical area, and their interactions. See Sections III and VI and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: The Relationship Between the Bison's Slaughter and Income, Banks, and Population Density from 1989-2019 by Access to Banks in 1870 and Bank Failures During the Great Depression

	Banks	Pop Dens	Income	Banks	Pop Dens	Income	Banks	Pop Dens	Income
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Exposed to Slaughter	-1.6242***	-2.2173***	-0.2599***	2.6724	1.5363	1.7245	-0.2004	-1.0911*	-0.1394
	(0.3164)	(0.3767)	(0.0719)	(4.7768)	(6.4791)	(1.1179)	(0.4246)	(0.5569)	(0.1210)
Exposed $\times$ Dist Bank 1870				-0.3404	-0.2890	-0.1545*			
				(0.3772)	(0.5065)	(0.0873)			
Ln(Dist Bank 1870)				0.01604	-0.05916	-0.02946***			
				(0.0356)	(0.0376)	(0.0064)			
Exposed $\times$ # Bank Failures							-1.2213***	-0.9288**	-0.1100
							(0.3415)	(0.4174)	(0.0896)
Ln(# Bank Failures)							1.2346***	1.2078***	-0.007484
							(0.2277)	(0.2372)	(0.0577)
Observations	407	407	405	407	407	405	407	407	405
Adjusted R^2	0.197	0.287	0.321	0.191	0.298	0.348	0.479	0.482	0.330
# Clusters	61	61	61	61	61	61	61	61	61

Notes: This table displays coefficient estimates from OLS specifications. In column (1), (4), and (7) the dependent variable is the natural logarithm of the number of banks in counties that overlap with reservations, weighted by the area of the overlap. In column (2), (5), and (8) it is the natural logarithm of population density in counties that overlap with reservations, weighted by the area of the overlap. In column (3), (6), and (9) it is the natural logarithm of per capita income for Native Americans living within reservation boundaries. All columns include year fixed effects, a control for the natural logarithm of the distance to the closest metropolitan statistical area, and their interactions. Columns (4)-(9) also interact the banking measures with year fixed effects. See Sections III and VI and Online Appendix Section **??** for more information, including data sources and variable construction. Standard errors clustered by Indigenous nation are in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$