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Buffalo Hunt: International Trade and the Virtual Extinction of the North American Bison[†]

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In the sixteenth century, North America contained 25 to 30 million buffalo; by the late nineteenth century fewer than 100 remained. While removing the buffalo east of the Mississippi took over 100 years, the remaining 10 to 15 million buffalo on the Great Plains were killed in a punctuated slaughter lasting little more than ten years. I employ theory, international trade statistics, and first-person accounts to argue the slaughter was initiated by a foreign-made innovation and fueled by a foreign demand for industrial leather. European demand and American policy failure are jointly responsible for the "Slaughter on the Plains." (*JEL* F14, N51, N71, Q57)

A little over 200 years ago, Meriwether Lewis and William Clark completed their epic voyage of western discovery. Their vivid account of the West's natural beauty and its limitless wealth spurred on thousands of Americans to carve out a new life and new nation west of the Mississippi. Westward expansion, with its stories of frontier hardship, shaped much of American national identity by showing how self-reliance, risk-taking, and hard work could tame a wild frontier. While the nineteenth century is surely one of the most inspirational periods in American history, it also bears witness to a less flattering record with regard to the environment: most significantly, the slaughter of the plains bison, or buffalo.[1]

This paper examines the slaughter using theory, empirics, and first-person accounts from diaries and other historical documents. It argues that the story of the buffalo slaughter is surprisingly not, solely, an American one. Instead, I argue that the slaughter was initiated by a tanning innovation created in Europe and maintained by a robust European demand for buffalo hides. Specifically, I argue that three conditions are jointly necessary and sufficient to explain the time pattern of buffalo destruction witnessed in the nineteenth century. These are: (i) a price for buffalo products that was largely invariant to changes in supply; (ii) open access conditions

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[1] The term "buffalo" is a misnomer, but I will use it throughout since this is common usage. The description of the kill as the "Slaughter on the Plains" is also conventional.

with no regulation of the buffalo kill; and (iii), a newly invented tanning process that allowed buffalo hides to be turned into valuable commercial leather.

In the sixteenth century, North America contained 25–30 million buffalo; by the late 1880s less than 100 animals remained wild in the Great Plains states.[2] While removing buffalo east of the Mississippi took settlers well over 100 years, the remaining 10 to 15 million were killed in a punctuated slaughter in a little over ten years. Standard explanations hold some combination of the United States Army, the railroads, and changes in native hunting practices responsible. My claim is that (i), (ii), and (iii) are both necessary and sufficient.

The argument I develop proceeds in three steps. First, I develop a simple model of buffalo hunting. Potential hunters differ in their skill, and there is costless entry and exit. I take world prices as given and assume throughout that hunting is not regulated. The model is made general equilibrium by the addition of a numeraire good sector which serves as the outside option for buffalo hunters. The model is made dynamic by assuming herd size grows via a conventional compensatory growth function and falls with the kill from hunters.[3]

The theory shows how the combination of an innovation in tanning, fixed world prices for hides, and open access to the herds proved fatal to the buffalo. An innovation in tanning makes previously useless buffalo a valuable commodity. New entrants pour in and the "harvest" of buffalo hides booms.[4] Fixed prices ensure the new supply of buffalo hides cannot dampen the incentive to hunt; open access ensures that regulations limiting the kill are not forthcoming; and the tanning innovation plus hunter heterogeneity delivers a punctuated slaughter.

The theory also shows why fixed prices are necessary. If prices adjust considerably to changes in supply—as they typically would if buffalo products had only a domestic market—then any large kill-off would have created excess supply, lowered prices, and dampened the incentive to hunt. When the herds were severely depleted, hide prices should have risen, perhaps increasing entry as the buffalo approached extinction. All of these predictions are inconsistent with the historical record. Because buffalo and cattle hide are very good substitutes in many uses, and the world cattle hide market was large, hide prices moved little in response to the slaughter.[5] And with little movement in prices, the dynamics of the slaughter are dominated by a boom and then bust in hunter numbers.

In sum the theory provides a *prima facie* case for the importance of international markets in the slaughter. Accordingly, the second step is to examine evidence on US exports of buffalo hides.

[2] The species *Bison bison* comes with two distinct varieties: the common plains bison and the less common woods bison found exclusively in Canada. I focus on the extinction of the plains bison in the United States, although I provide a short discussion of the quite different Canadian case in Section IV.

[3] The model is an extension of James A. Brander and Taylor (1997) to allow for hunter heterogeneity. It also bears some resemblance to resource models with entry such as Don Patterson and James E. Wilen (1977).

[4] The pace of the slaughter was such that many contemporary writers thought extinction was all but inevitable. Joel A. Allen, writing in 1876, said, "The fate of none of our larger animals is more interesting than is that of the bison, since total extermination is eventually surer to none than to this former monarch of the prairies" (Allen 1876, p. 71).

[5] Direct evidence on hide prices is provided in Table 1, while evidence showing the United States was indeed small on the world hide market is presented in Section V. See Taylor (2007) for an analysis showing demand must be sufficiently elastic, and prices therefore unresponsive to supply shocks, for the innovation to generate a boom and bust pattern.

A natural consequence of the rapid elimination of the buffalo is that records of the number killed are nonexistent, and only very partial shipping records exist. US trade statistics from the nineteenth century contain categories of exports that contain buffalo products, but no individual entry is labeled "buffalo meat," "buffalo robes," or "buffalo hides."[6] The key series I employ is "hide and skins exports," but this surely contains both cattle and buffalo hides. To solve this problem, I employ economic theory and independent work on the US cattle cycle to construct a time series of buffalo hide exports. This constructed series is then cross-checked for consistency against several pieces of independent evidence. The cross checks examine the magnitude of the implied exports, their timing, and their geographic variation. I also find supporting evidence of buffalo hide exports in newspaper accounts, personal diaries, business directories, auction notices, and hide price quotes in several European countries.

In addition, I examine import data from Canada, the United Kingdom (UK), France, and Germany to develop an alternative quasi-experimental approach to estimating buffalo hide exports. This method produces another series of (implied) buffalo hide exports, and comparing these two series provides a further check on my analysis.

The final step is to argue that the newly constructed export data support the export-driven slaughter hypothesis, while the evidence for the alternative hypotheses that hold the railroads, the Army, or native Americans responsible is far weaker. The magnitudes of the implied export flows are considerable. My findings suggest approximately six million buffalo hides are exported over the 1871–1883 period, and this represents a buffalo kill of almost nine million. The timing of greatest export flows fits the historical record extremely well, as does the variation across the country of imports. The two alternative measures of buffalo hide exports, constructed using different data and methods, provide very similar results.

There is a huge literature studying the buffalo and other related aspects of westward expansion in the nineteenth century. This literature includes literally hundreds of contributions from history, political science, and sociology, but only a handful from economics. Perhaps the best known contribution is the 1889 monograph by William Temple Hornaday, who was then chief taxidermist of the Smithsonian Institute. Hornaday's monograph *The Extermination of the American Bison* is the classic account of the elimination of the buffalo both east and west of the Mississippi. Hornaday collects figures on the number killed from various sources and provides the first definitive account. Hornaday, however, makes no mention of international trade. Other classic contributions, such as *The Plains of the Great West* by Richard I. Dodge (1877) and Joel Allen's 1876 contribution *The American Bisons: Living and Extinct*, offer us vivid first-person accounts (in the case of Dodge), and a scholarly examination of the process from a naturalist at Harvard, but neither seeks to identify the underlying cause.

More recent work by economists includes that of Dean Lueck (2002) and Bruce L. Benson (2006), who focus on property rights issues, and a series of papers by economic historians linking market forces to the depletion of renewable resources

[6] There are a couple of minor exceptions to this statement. For example, dispatches to the State Department from the US consul in Winnipeg, James Wickes Taylor, from 1871–1887 sometimes refer to buffalo products shipped from Canada. Most of these products, however, were shipped in bond on their way to Montreal. See Gerald Friesen (1988) for an analysis of Taylor's reports over this period.

in earlier centuries.[7] Prominent among these are the series of papers by Ann M. Carlos and Frank D. Lewis (1993, 1999), who examine the depletion of beaver in the eighteenth century; Patterson and Wilen (1977), who study the northern Pacific fur seal hunt; and most recently Robert C. Allen and Ian Keay (2004), who study the extinction of the Arctic Bowhead whale.

The work presented here differs from earlier contributions in several ways. Most important, the focus here is on the "slaughter." There is no real mystery as to why the buffalo were eliminated from their previous ranges. What is surprising is the rate of killing and its variation over time: one half of the precontact buffalo population was killed in just ten years' time post 1870; the elimination of the other half took over 100 years.

This focus on the *slaughter* is important, because it suggests international markets may have soaked up the excess supply while leaving prices constant. Investigation of this possibility led to the major contribution of this work: the identification of international trade as a key driver in the process. The earlier contributions from economic history explored rather different positive and normative questions, and in each case there was little debate as to the ultimate cause of resource depletion.[8] In contrast, I argue that the usual suspects held responsible for the "Slaughter on the Plains" are in fact innocent.

An examination of the slaughter also provides important case study evidence on the speed with which property rights institutions can adapt in the face of new circumstances. In this case the changed circumstance was an innovation, and the adjustment, as measured by new regulation, was slow. In contrast, market responses were immediate and powerful. This relative speed of adjustment is key to many policy debates, and given the dearth of empirical evidence directly on point, case study evidence can be of great value. In this respect my analysis is related to that of Lueck (2002) who seeks to understand why property rights did not emerge for the bison. Lueck's answer is that domestication was too costly given bison's demeanor and the need for large (fenced) areas for grazing. Instead, I will argue that the world hide market effectively set a fixed value for bison hides independent of their supply, and this limited the economic incentives for conservation or regulation.

Looking back to our past provides us with guidance for the future. Many developing countries in the world today are heavily reliant on resource exports, and few, if any, have stringent regulations governing resource use. The globalization pressures these nations face, and the policy choices they have to make, are not too different from those faced by the United States in the late nineteenth century. These choices are informed by an expanding literature investigating the environmental consequences of international trade. This article makes two contributions to this literature. First, while it is well known that international trade can magnify any market failure present in autarky, finding significant and empirically verifiable examples of

[7] An early and excellent discussion of the slaughter, the hide trade, and the attempts to legislate hunting is contained in John Hanner (1981). See also Scott Farrow (1995).

[8] International trade in beaver is central to several of the contributions by Carlos and Lewis: Carlos and Lewis (1999) is perhaps the closest to this work since it adopts a small open economy model and a price shock is the driver of depletion. Their focus, however, is on how differences in local competition for beaver pelts across Hudson's Bay Company trading posts affects the transmission of this shock to native hunters and, hence, affected the local depletion of the beaver.

resource overuse tied to trade has proven to be quite difficult.[9] This is not surprising: less developed countries are the least likely to carefully record resource use and, in the case of renewable resources, the impact of policy failures can take years to manifest themselves. But years of observations carry with them alternative causes and confounding factors, making a clean cut case difficult to establish. Given the speed of the buffalo slaughter, and the availability of data that I will present, it offers us a perhaps unique opportunity to identify the role of trade and measure its impact.

Second, while the buffalo slaughter is a dramatic example of resource overuse arising from open access, it also forces us to ask why property rights solutions were not forthcoming. In recent work building on Harold Demsetz's (1967) original thesis, Brian R. Copeland and Taylor (2009) argue that price increases such as that experienced in the buffalo case can provide the incentives needed for better resource management. Price increases, however, may need to be large to facilitate change, and other conditions also matter.[10] In this case, a limited value for the buffalo, plus difficulty in defining and enforcing property rights, combined to limit these solutions.

The rest of the article proceeds as follows. In Section I, I provide important background material on the history and biology of the buffalo that is generally not well known. In Section II, I construct a hunting model to examine how the time path of buffalo kills responds to an unexpected tanning innovation. In Section III, I construct the buffalo hide–export data and provide a series of cross-checks. Section IV evaluates the alternative hypotheses, while Section V discusses the world hide market. Section VI concludes.

I. History and Biology

Buffalo are the largest terrestrial mammals in North America and have been since the Pleistocene extinctions over 10,000 years ago. The earliest recorded European observations came from Spanish explorers in the early 1500s who remarked on the vast herds of native cattle in present day Mexico. Similar observations were subsequently made by French and English explorers in other regions of North America. The newcomers were unanimous in their appraisal of buffalo as "innumerable" or "countless," and the country was famously described as "one black robe" of buffalo.[11]

Since extrapolating from any first-person account can lead to serious error, it is not surprising that early estimates of the buffalo population vary from over 100 million to less than 20 million.[12] The most reliable estimates come to a figure somewhere between 25 and 30 million buffalo. These estimates are constructed by multiplying

[9] For theory see Graciela Chichilnisky (1994) and Brander and Taylor (1997); and for empirics see Ramon Lopez (1998).

[10] See, for example, Copeland and Taylor (2009), especially Section 4.3 on forests, and original empirical work in this area by Foster and Rosenzweig (2003) and Henning Bohn and Robert T. Deacon (2000).

[11] The American explorers, Lewis and Clark, met buffalo at many points along their voyage of discovery. On their return voyage in 1806 at the mouth of the Yellowstone river where it meets the Missouri, they recorded: "The buffalo now appear in vast numbers. A herd happened to be on their way across the river [the Missouri]. Such was the multitude of these animals that although the river, including an island over which they passed, was a mile in length, the herd stretched as thick as they could swim completely from one side to the other, and the party was obliged to stop for an hour" (Hornaday 1889, p. 389).

[12] The naturalist Ernest Thompson Seton (1909) estimated the population circa 1600 at 75 million, but with little factual basis. The historian Dan Flores (1991) employed a more transparent method to arrive at a figure of 27 million.

the carrying capacity on agricultural land with estimates of the original buffalo range of almost three million square miles. With the exception of New England, buffalo were found in all of the lower 48 states, the four westernmost Canadian provinces and its two territories, and the northernmost part of present day Mexico.

A. *Habitat Destruction and Subsistence Hunting*

The buffalo east of the Mississippi were removed through a combination of habitat destruction and subsistence hunting. The gradual removal of buffalo proceeded westward when settlers crossed the Allegheny mountains into Kentucky in the early 1800s. It continued unabated for the next 50 years as settlers moved towards the "Great Plains" at approximately the 98th meridian. By 1830, buffalo were largely gone east of the Mississippi. During much of this early period natives hunted the buffalo not only for their own subsistence needs but also to trade buffalo robes at forts and towns. A buffalo robe is the thick and dark coat of a buffalo that is killed mid-winter. Robes could be used as throws for carriages, or cut to make buffalo coats and other fur items. They were a common item in the 19th century, and they made their way to eastern markets via transport along the Missouri river to St. Louis or overland via the Santa Fe trail. In the 1840s settlers pushed through the Great Plains into Oregon and California. The movement of the 49ers to California and the Nevada gold rush years brought a steady stream of traffic through the Platte River valley. Subsistence hunting along the trail plus the movement of cattle and supplies divided the existing buffalo herd into what became known as the Northern and Southern herds.

The division of herds became permanent with the building of the Union Pacific Railroad through the Platte River valley in the 1860s. While subsistence hunting for the railroad crews surely had some effect on buffalo numbers, as did the railroad's popular day trips to kill buffalo, the harried buffalo herds withdrew from the tracks, creating a corridor centered on the Union Pacific line.[13] The railroads also provided transportation for buffalo products to eastern and foreign markets, but in the 1860s railway cars were not refrigerated, and, hence, buffalo meat was marketed only as salted, cured, or smoked.

Despite the railroads, the market for buffalo robes, the increase in subsistence hunting, and the conversion of the high prairie to agriculture, most observers expected the population to decline gradually as it had east of the Mississippi.[14] The force of habitat destruction was minimal on the Great Plains. In 1860, they held only 164,000 people. Farms occupied less than 1 percent of the land area.[15]

[13] To see why subsistence and sport hunting could make only a small dent in the herd a little calculation is helpful. If the carrying capacity of the Great Plains was 15 million buffalo, and if we take their intrinsic growth rate at 0.2, then (using the logistic growth equation for the buffalo) a maximum sustainable yield population of 7.5 million allows for a yearly sustainable kill of 750,000 buffalo. To put this in perspective, the most famous buffalo hunter ever known—Buffalo Bill Cody—was an entrepreneurial young boy of 18 when he offered to supply the Union Pacific workers with buffalo meat. William Cody got the contract with Union Pacific, but even his own (perhaps inflated) accounts indicate he killed only 4 to 5 thousand buffalo per year. Hornaday claims that killing by whites, natives, and "half-breeds" totaled less than 500,000 before 1870 and was sustainable (Hornaday 1889, p. 466).

[14] See, in particular, Hanner (1981).

[15] See Lueck (2002), Table 4.

The Civil War brought a temporary reprieve for the buffalo. Major battles occurred in regions with few or no buffalo, and this provided a break from the slow but steady destruction that had marched westward. Despite this reprieve, settlement and habitat destruction had taken a toll: estimates of the buffalo population circa 1865 range from 10 to 15 million.

B. *The Innovation*

The temporary reprieve ended quickly when, in 1870 or 1871, tanners in England and Germany developed a method for tanning buffalo hides into useful leather. While natives commonly tanned the thick-haired buffalo hides taken in winter months into buffalo robes, their process was laborious and required ingredients from buffalo themselves (the brain, liver, and fat or tallow). A cheap simple commercial process for conversion into leather was as yet unknown. Various historical accounts attribute the breakthrough to tanners in Germany and still others to English tanners. Many accounts suggest the "innovation" was imitated by US tanners, but exactly when and where this imitation occurred is unclear.[16]

There are several elements of the innovation that are important to discuss: the timing, the initial location of the innovation in one or more foreign countries, the fact that it represented a shock to the buffalo hunting industry, the use to which buffalo hides were put once tanned, and the eventual diffusion of the innovation to other countries.

The hardest evidence comes from a *London Times* article reporting from New York City in August of 1872. It reports that a few enterprising New Yorkers thought that buffalo hides might be tanned for leather, and when the hides arrived they were "sent to several of the more prominent tanners who experimented upon them in various ways, but they met with no success. Either from want of knowledge or a lack of proper materials, they were unable to render the hides soft or pliable, and therefore they were of no use to them."

The report continues to note "several bales of these hides were sent to England, where they were readily taken up and orders were immediately sent to this country for 10,000 additional hides. These orders were fulfilled, and since then the trade has continued." Further still, the methods are spelled out: "The hides are collected in the West by the agents of Eastern houses; they are simply dried, and then forwarded to either New York or Baltimore for export… The low price that these goods have reached on the English market, and the prospect of a still further decline, may in time put an end to this trade, but *at present the hides are hunted for vigorously*, *and*, *if it continues*, *it will take but a few years to wipe the herds out of existence*"[17] (my emphasis).

[16] I have been unable to find records of a "buffalo hide tanning" patent during this period. This is perhaps not surprising as Petra Moser (2010), using data on innovations presented at World's Fairs from 1851–1910, finds most innovations were not patented (for example, 89 percent of innovations in the United Kingdom and 85 percent of innovations in the United States were not patented); finds patenting especially uncommon in industries like tanning that rely on chemical processes; and finds these same patenting patterns are true for even high value innovations.

[17] It appears this article is unknown to other researchers: see "Buffalo Hides: Some eight or ten months ago," *The Times*, August 17, 1872, p. 4, Issue 27458, col. F. It is not known who the enterprising New Yorkers were, although one possibility is William C. Lobenstein (a pelt dealer with an office in Leavenworth, Kansas) who "is well known as the first dealer to introduce buffalo hides to the market" (*Fort Griffin Echo*, April 19th, 1879). Lobenstein later lived on the Upper East Side of Manhattan.

Similar accounts come from interviews or diaries of buffalo hunters. For example, while the *London Times* article places the innovation in the fall of 1871, the diary account of buffalo hunter George "Hodoo" Brown places it somewhat earlier. Returning from a meat hunting trip in May of 1871 to Fort Wallace, Brown had the following conversation with fellow hunters at the fort:

> *We told them the weather was getting so warm it was almost impossible to get meat to market before it spoiled. They said to me, 'Why don't you skin them and just take the hides, and let the meat lay?' I says, 'What the devil would I do with the hides?' One man said, 'Ship them to Leavenworth to W. C. Lobenstine. He'll buy your hides and send a check.' So Burdett and I on our next trip went to skinning.*[18]

Similarly, J. Wright Mooar recounted that

> *In the winter of* 1871 *and the spring of* 1872, *Lobenstine apprised Charlie Rath of the fact that an English firm had asked for five hundred buffalo hides, to be used as an experiment in making leather; and if successful, they would take an unlimited number of the hides, which would open up an immense trade in a new kind of leather to be placed on markets of the world. Among others, I was now killing buffalo for the meat, and became interested in the enterprise, and agreed to enter actively into the work of killing buffalo, and thus furnish my pro rata of the first five hundred.*[19]

Numerous secondary accounts are also available in the literature, and putting these accounts together it appears the innovation was made in England and Germany at roughly the same time in late 1870 or early 1871.[20] Importantly, it appears that US tanners were unable to tan buffalo hides at this time.

These early accounts also attest to the novelty of buffalo hides as a potentially valuable commodity. Both Hodoo Brown and Mooar were meat hunters before the innovation, but hide hunters after—along with the legion of others that soon entered the now lucrative hide hunting business. It is less clear how tanned buffalo leather was used, and why it had such a strong foreign demand. The literature mentions two uses for the leather. The first was for sole leather, with a burgeoning European demand coming from refitting armies in the post-1870 period. Specifically, several sources mention the British Army and its demand for buffalo leather as it was tougher and thicker than many cattle hides.[21]

In addition to sole leather, the tough buffalo hides found use as industrial belting for machinery in England and elsewhere on the European continent. Many secondary sources make this connection, but primary source evidence is also

[18] Interview with George W. Brown reported in Miles Gilbert, Leo Remiger, and Sharon Cunningham (2003, p. 55).

[19] As told to James Winford Hunt and published in *Buffalo Days: Stories from J. Wright Mooar*, edited by Robert F. Pace. See Pace (2005, p. 17–18).

[20] For example, Wayne Gard (1960, p. 90), notes: "In 1870, J. N. DuBois, a Kansas City dealer in hides, furs and wool shipped several bales of buffalo hides to Germany, where tanners had developed a process for making them into good leather."

[21] I have been unable to find a contract linking the British Army with a US hide dealer. The evidence for its involvement is circumstantial, but its demand for sole leather is huge. For example, "Army butt" is a specific cut of sole leather for the Army; and the British Army contracted out for 714,943 boots and shoes in 1878 alone. See *Report of the Director of Army Contracts* for the year ended 31st December, 1878, p. 11.

available from English business directories. For example, Slater's Royal National Commercial Directories at the time list numerous tanners, hide merchants, and leather belt manufacturers in their directory of trades. These businesses list as products buffalo hides, buffalo skips, buffalo hide shavings, buffalo pickers, and strapping for cotton gins.[22]

The eventual diffusion of the innovation to the United States is difficult to establish though often claimed in the literature. For example, Mooar's account quoted above mentions a shipment of 57 hides to his brother John in New York for tanners there to experiment with.[23] The best evidence of diffusion of the innovation to US tanners comes from New York Chamber of Commerce Annual reports that list prices for hemlock-tanned sole leather made from a variety of hides (Buenos Ayres, California, etc.). These price quotes do not include bison in the early 1870s, but price quotes for bison tanned leather soles first appear in the 1877/1878 report, continue for 1878/1879, and then disappear the following year. This suggests the innovation may have diffused to US tanners by the late 1870s.[24]

Evidence for diffusion to other European countries is much better, as I have been able to find price quotes, auctions, and advertisements in trade journals covering Hamburg (Germany), LeHavre (France), and Liverpool (United Kingdom). For example, the *Shoe and Leather Reporter* lists North American bison price quotes in the Hamburg market in 1876; auction announcements appear frequently in the *Liverpool Mercantile Gazette* from 1871 through to its end of publication in 1875; and the French weekly *La Halle Aux Cuirs* lists bison shipments arriving in the port of LeHavre in 1873, 1874, 1875, and 1876.[25] These data confirm that significant shipments of bison to French, German, and British markets did occur at least during the early to mid-1870s. For example, in 1873 the bison auctions in Liverpool sold 93,498 hides, but private sales and contracting (which were the primary means of sale) are unaccounted for, as are hide shipments through other UK ports.[26]

[22] See, for example, in *Slaters Business Directory, 1879 for Manchester and Salford*, advertising by John Tullis and Son Tanners and Curriers and Leather Belt Manufacturers, p. 80; the list of hide dealers and merchants, p. 103; the advertising by Heyworth and Law Tanners and Curriers and manufacturers of Machine Belting, p. 126; the advertising of Hepburn and Sons, Tanners and Curriers and Leather Factors, p. 85.

[23] Mooar's shipment of 57 hides to his brother in New York and subsequent contracts for more hides is often mentioned as evidence of involvement by the US tanning industry. To investigate, I explored Mooar's papers, held at the University of Texas at Austin. Although the ledgers and day books are in poor condition, they indicate no hide sales to tanners but several to W. C. Lobenstein. See Josiah Wright and John Wesley Mooar Papers, 1838–1934, Center for American History, University of Texas at Austin.

[24] Other evidence of eventual diffusion comes from an article in the trade journal *The Shoe and Leather Reporter*, in January of 1878, p. 91. Under a title "Bison Hides," it notes, "The trade in bison hides is quite a large one, and it is now thought that these animals which roam our Western prairies in such vast herds will before many years become extinct… One firm in Leavonworth Kan., dispose of 150,000 of these hides yearly… There are only two or three tanners East engaged in getting out bison leather, but a large tannery in Cincinnati is running on them… The hides were sent to Europe to some extent a few years ago, but not many go over now."

[25] See, for example, *Shoe and Leather Reporter*, Thursday, September 21, 1876, Vol. XXII, No. 12, p. 331 titled "European Continental Markets"; see the *Liverpool Mercantile Gazette,* March 1871, 1872 (volume missing), 1873 (every month except December), 1874 (volume missing), and 1875 January to June when the publication ceases to exist. Finally, see the shipments section of *La Halle Aux Cuirs*, January and February 1873; March and September 1874; February, July, and December 1875; and April 1876.

[26] The other major ports were London, Hull, Bristol, and Clyde and Leith. Liverpool as a fraction of hide imports ranges from 18 percent to 22 percent from 1871 to 1874. For a table listing import figures across ports, see the *Liverpool Mercantile Gazette*, Monday, January 4, 1875.

C. *The Flint Hide Market*

Regardless of the innovation's source, its effect on the Great Plains was electrifying. The market for buffalo hides boomed; buffalo hunters already in the field—like George "Hodoo" Brown—started to skin buffalo for their flint (hairless) hides, and hundreds if not thousands of others soon joined in the hunt. Previous to the innovation, hides taken from the Southern herd or hides taken in all but three winter months were virtually worthless as fur items. The only saleable commodity from a buffalo killed in these regions or times was its meat, but this market was severely limited by transportation costs. With the advent of a flint-hide market, killing a buffalo anywhere and anytime became a profitable venture. By 1872, a full-scale hide boom was in progress.

Although no accurate figures are available, Colonel Richard Irving Dodge (of Dodge city fame) estimated the buffalo kill in Kansas at close to three million buffalo over the 1872–1874 period.[27] Once the herd in Kansas disappeared, the hunters turned south towards present day Oklahoma, western Texas, and eastern New Mexico. The business of hide hunting did not last long—less than seven years in Kansas and areas to the south. And when the Southern herd was eliminated in 1879, many hide hunters looked north to the only significant herd left in existence. The key bottleneck in the north was the still hostile Sioux. After the defeat of the Sioux in the late 1870s, the Northern Pacific Railroad extended its tracks west from Bismarck into the heart of the Montana plains, reaching Glendive in 1880 and Miles City in 1881. The Northern herd was already diminished by the robe trade that, as early as 1850, sent 200,000 to 300,000 robes yearly down the Missouri.[28] With easy transportation and the elimination of the Indian threat, hide hunters flooded the northern range. Hide hunting in the north reached a peak in 1881 or 1882, and by 1883 the commercial hide hunt was faltering. In 1884, the last of the flint hides were shipped east.[29]

D. *The Road to Conservation*

In 1886, William Templeton Hornaday urged his superiors at the Smithsonian to fund an expedition to kill and mount a group of buffalo for posterity. It took Hornaday two expeditions, four months of effort, and the help of professional hunters to finally succeed in collecting specimens for his innovative diorama of buffalo on the Montana plains. At this time, Hornaday estimated there were fewer than 100 wild buffalo in the Great Plains states.[30]

The slaughter of the North American buffalo surely represents one of the saddest chapters in American environmental history. To many Americans at the time, the slaughter seemed wasteful and wrong, as many newspaper editorials and letters to congressmen attest, but still, little was done to stop it. The destruction of the buffalo and the wanton slaughter of other big game across the West did, however, pay some

[27] See Dodge (1877).
[28] See Charles M. Robinson (1995).
[29] See Hanner (1981).
[30] In response to the rising scarcity several ranchers thought it worthwhile to capture and breed bison. Famed Texas Rancher Charles Goodnight obtained several buffalo from the panhandle that were remnants of the great Southern herd. These animals became one of five foundation herds in the United States from which almost all present-day bison are descended. Other bison herds were collected and some of these became the foundation stock for the Yellowstone herd set up in the early 1890s.

dividend. The slaughter of the buffalo in particular was pivotal in the rise of the conservation movement in the late nineteenth and early twentieth century. Almost all of the important players in the conservation movement experienced the slaughter firsthand—Teddy Roosevelt, John Muir, and William Hornaday.[31] The creation of the national park system in general, and the Yellowstone herd in particular, reflect the revulsion many felt to the *Slaughter on the Plains*.

II. The Model

I develop a simple dynamic model where agents hunt for buffalo or work in the outside good sector. Buffalo hunters were typically young single men with relatively low opportunity costs and limited skills. Many were Civil War veterans or new immigrants who had moved west seeking their fortune. Their alternative occupations as laborers in frontier towns, cattle punchers, soldiers, or railroad crew workers rarely paid very well.[32] To someone with limited skills, except perhaps with a rifle, buffalo hunting was a potential road to riches.

Not surprisingly, entry and exit from buffalo hunting was common. Since the entry and exit margin is so important to capture, I allow the number of active hunters to be determined endogenously while representing the pool of potential hunters by a continuum of agents with mass N.

A. *Individual Decisions*

I assume potential hunters differ in their hunting skill but are equally productive working in any one of the number of low-skilled occupations represented by the outside good sector. If an agent hunts, he earns the value of harvest ph over the next increment of time dt, where h is the quantity of buffalo killed and p the price of buffalo products obtained. If the hunter remains in the outside good sector he earns the value of his marginal product given by his wage w. All prices and costs are measured in terms of the outside good, which I take as the numeraire; therefore p is the relative price of buffalo products.

Let $S(t)$ denote the size of the buffalo herd in physical units at time t. Then assuming a hunter's productivity is proportional to the size of the herd, a hunter with skill α earns $ph = p\alpha S(t)$ per unit time. To allow for skill differences across hunters let $\alpha \in [0, \bar{\alpha}]$ with $F(\alpha)$ being the distribution function of hunting skill.[33] With these assumptions in place the *marginal hunter*, if one exists, is defined by his/her productivity, α^*, such that: $p\alpha^* S = w$ where the dependence of S on time has been suppressed. Assuming free

[31] The badge worn by National Park Service employees features a buffalo bull modeled after the bull killed and mounted by Hornaday in his buffalo diorama. Hornaday became the first director of the Bronx Zoo and was the first head of the American Bison Society. The buffalo bull immortalized on the buffalo nickel was modeled after a large bull in the live buffalo collection created by Hornaday at the Bronx Zoo. There are numerous Hornaday awards given by conservation groups all across America.

[32] Teddy Roosevelt described them as "absolutely shiftless and improvident; they had no settled habits; they were inured to peril and hardship, but entirely unaccustomed to steady work; and so they afforded just the materials from which to make the bolder and more desperate kinds of criminals" (Theodore Roosevelt 1889, p. 13). More detailed personal accounts are compiled in Gilbert, Remiger, and Cunningham (2003).

[33] Some productivity figures are available in the literature; for example, W. S. Glenn reports that a remarkable hunter can kill 75–100 per day; an average hunter 50; a common hunter 25, and others hardly enough to run a camp. See R. W. Strickland (1949).

entry and exit, we obtain a simple division of agents at any point in time. Any agent with skill $\alpha \geq \alpha^*$ hunts; the remainder work in the outside good sector.[34]

B. *Resource Constraints*

Two aggregate constraints close the model. If the mass of potential hunters is N, and the total *number* of active hunters is $N[1 - F(\alpha^*)]$, then $NF(\alpha^*)$ must work in the outside good sector. Since $\alpha^* > 0$, the outside good is always produced, and choosing units such that output equals labor input, $w = 1$ at all times.

The second constraint links the buffalo kill to the evolution of herd size. Define $\overline{K}(\alpha^*, S)$ as the number of buffalo killed per unit time when the herd is of size S, and agents with productivity no less than α^* are engaged in buffalo hunting; that is:

$$\overline{K}(\alpha^*, S) = SN\int_{\alpha^*}^{\overline{\alpha}} \alpha f(\alpha) d\alpha, \tag{1}$$

where the density of buffalo hunters with productivity α is $F'(\alpha) = f(\alpha)$, their mass is $Nf(\alpha)$, and their productivity in hunting is αS. I refer to 1 as the kill function. Since the marginal hunter is determined at every moment in time by the prevailing price and herd size, the kill function can be rewritten more succinctly as $K(p, S) \equiv \overline{K}(\alpha^*(p, S), S)$.

To determine how the kill responds to herd size, differentiate $K(p, S)$ to obtain: $dK(p, S)/dS = N\int_{\alpha^*}^{\overline{\alpha}} \alpha f(\alpha) d\alpha - NS\alpha^* f(\alpha^*) d\alpha^*/dS > 0$, where $d\alpha^*/dS < 0$. When the herd grows in size the productivity of inframarginal hunters rises, and lower skilled hunters enter; therefore, buffalo kills rise with herd size. When the herd shrinks, productivity drops and agents exit. As a result, there will exist a herd so small that only the most skilled find it worthwhile to hunt. Since the highest productivity hunters have productivity $\overline{\alpha}$, the *smallest huntable herd*, $S_S(p)$ is defined by: $p\overline{\alpha}S_S = w$. Rational agents will never hunt a herd if $S < S_S(p)$. Taking this into account, the kill function is zero if $S < S_S(p)$ and is given by $K(p, S)$ if $S_S(p) \geq S$.

To determine the dynamics of herd size, I assume bison grow according to a standard growth function drawn from resource economics. Biological growth, $G(S)$, is assumed to be a positive (strictly) concave function of herd size. Natural growth is zero when the buffalo are gone $G(0) = 0$, and zero when the buffalo reach the carrying capacity of the Great Plains, $G(C) = 0$.[35] The evolution of herd size can now be written as: $\dot{S} = G(S) - K(p, S)$.

[34] There were fixed and sunk set-up costs in hunting which I am ignoring here for simplicity. An earlier version of the model allowed potential hunters to make a truly dynamic investment decision. The more complicated model yielded predictions very close to those given by this simpler setup. Occam's razor, and seminar participants, pushed me to adopt the simpler specification.

[35] Bison, like almost all renewable resources, will cease to regenerate at extremely low population levels. This can be due to long-run considerations such as a lack of the necessary genetic diversity, or shorter-run considerations such as the failure to find a mate in a depopulated environment. The growth function $G(S)$ ignores these possibilities. I will, however, report important qualifications that arise if we allow for a minimum viable population of C_0 by assuming a common alternative featuring critical depensation given by: $G(S) = rS(S/C_0 - 1)(1 - S/C)$, where r is the intrinsic rate of resource growth and C the carrying capacity.

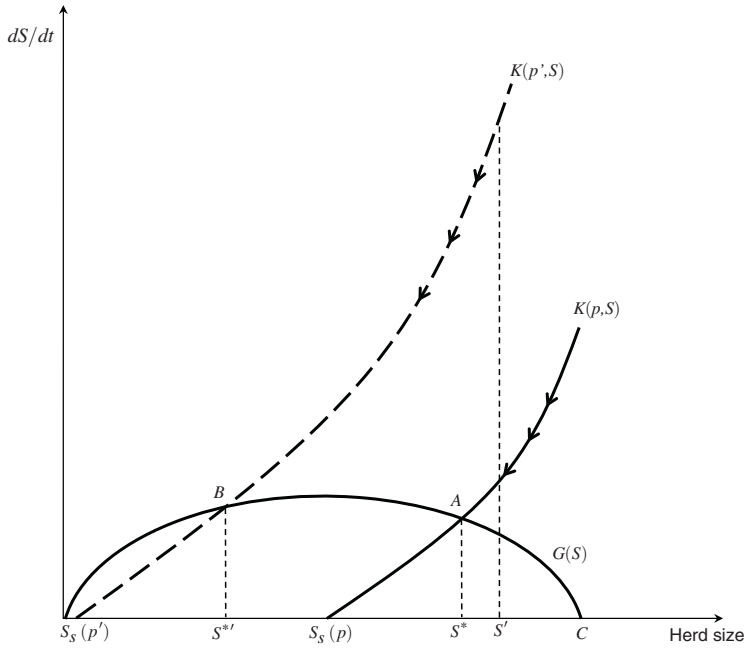

FIGURE 1. THE STEADY STATE

C. *Steady State Solution*

A typical interior steady state is shown in Figure 1 at point A (ignore for the moment the other steady state at B). The growth function $G(S)$ starts at $S = 0$, rises, and then returns to zero growth when the herd reaches its carrying capacity at C. Two kill functions are shown, but for now, consider only the bolded $K(p,S)$ intersecting $G(S)$ at A. $K(p,S)$ is zero for small herd sizes $(S < S_S(p))$, but at $S_S(p)$ hunting begins and then grows in intensity. The kill functions are not necessarily convex (as shown), but even when they are not, under mild conditions, there is a unique interior solution for any given $p > 0$.

PROPOSITION 1. *Assume: $C > S_s$, then there exists*

(*i*) *a unique interior steady state herd size $S^* \in [S_S, C]$;*

(*ii*) *a unique marginal hunter $\alpha^*(p,S^*) \in (0,\bar{\alpha})$; and,*

(*iii*) *starting from any $S > 0$, convergence to S^* is monotonic.*

PROOF:

See footnote below.[36]

[36] **Proof to Proposition 1.** Suppose not. Let both $S_1 \neq S_2$ solve $K(p,S) = G(S)$. Let $0 < S_1 < S_2$, then $G(S_1)/S_1 > G(S_2)/S_2$ by the strict concavity of G. Since $K(p,S_1) = G(S_1)$ and $K(p,S_2) = G(S_2)$, $K(p,S_1)/S_1 > K(p,S_2)/S_2$, or $N\int_{\alpha_1^*}^{\bar{\alpha}} \alpha f(\alpha)d\alpha > N\int_{\alpha_2^*}^{\bar{\alpha}} \alpha f(\alpha)d\alpha$. Note $\alpha_1 = w/pS_1 > \alpha_2 = w/pS_2$; hence, $N\int_{\alpha_1^*}^{\bar{\alpha}} \alpha f(\alpha)d\alpha > N\int_{\alpha_1^*}^{\bar{\alpha}} vf(\alpha)d\alpha + N\int_{\alpha_2^*}^{\alpha_1^*} \alpha f(\alpha)d\alpha$ implies $0 > N\int_{\alpha_2^*}^{\alpha_1^*} \alpha f(\alpha)d\alpha$, which is a contradiction. The uniqueness of α^* follows directly.

Uniqueness and existence are guaranteed by very weak conditions. If the carrying capacity is greater than the smallest huntable herd then $C > S_S(p)$ as shown, and $p\bar{\alpha}C > w$. This implies buffalo hunting provides rents to the most productive hunters when the herd is close to carrying capacity, and, hence, entry is profitable. The steady state also determines the number of hunters $N[1 - F(\alpha^*)]$, their aggregate kill $K(p, S^*)$, and output of the outside good $NF(\alpha^*)$. Starting from any positive stock level $S > 0$, convergence to the steady state is monotonic.[37]

D. *Slaughter on the Great Plains*

For the most part I focus on the destruction of the Southern herd, as this was the immediate result of the tanning innovation and signaled the introduction of the flint hide market.

The introduction of buffalo hide tanning was a positive price shock for buffalo products. Before the tanning innovation, a buffalo hunter would kill for some combination of the animal's meat (including the tongue) and, if in season, perhaps its robe. Prior to the innovation, hunters of the Southern herd were almost exclusively meat hunters, but once the tanning of buffalo hides was possible, the value of a kill was soon dominated by the value of a hide. Historic accounts are clear that the introduction of the hide market vastly increased the return to buffalo hunting so that most meat was left to rot on the plains, and killing took place in regions where robes were of poor quality (much of the southern United States) and at times of the year when robes were worthless. All of this implies we should model the impact of the tanning innovation as raising the value of a buffalo kill from p to p'.

The historical account is also fairly clear that before the tanning innovation, buffalo numbers were falling, although slowly. To capture this feature of the pre-1870 period, I assume the economy was operating somewhere along its transition path to an initial steady state when the price shock hit.

Destroying the Southern Herd.—Reconsider Figure 1. Prior to 1870 the value of a buffalo kill was given by p, and, hence, the kill function $K(p, S)$ intersects the horizontal axis at $S_s(p)$; the corresponding steady state is given by A. I assume the economy was moving along $K(p, S)$ towards the steady state at A from the right. Buffalo numbers were falling, but slowly.

The tanning innovation changed all that. When the price shock hits, the economy is at a point like S'. The kill function shifts to $K(p', S)$, dramatically raising the kill because the hunting skill needed to justify entry drops discretely from $\alpha^*(p, S')$, to $\alpha^*(p', S')$. The flood of new entrants raises the buffalo kill abruptly, and the slaughter begins. Relatively high cost hunters enter today, but as the boom unwinds these same hunters retire from buffalo hunting. Only those with very low hunting costs remain as the economy moves towards its new steady state at B.

[37] With critical depensation things are a little more complicated. If $C_0 > S_S$, then extinction may be the only steady state; alternatively, if $S_S > C_0$ there exists at least one interior steady state with herd size $S^* \in [S_S, C]$ and associated marginal hunter $\alpha^*(p, S^*) \in (0, \bar{\alpha})$. This steady state is locally stable. Uniqueness of this interior steady state can be guaranteed by placing restrictions on the distribution of hunting ability across the population.

It is apparent from the figure that both the buffalo herd and the number of buffalo hunters adjusts when prices rise. In theory, the steady state buffalo kill may rise or fall in response. The kill rises if the buffalo herd exceeded $C/2$ prior to the price shock and the price shock itself was marginal. In all other cases it falls. Since Hornaday estimated that fewer than 100 buffalo were left by the late 1880s, while C is perhaps 25 million, the $S^* < C/2$ case is most relevant. In this case, the aggregate kill, in steady state, falls with the price shock.[38]

Destroying the Northern Herd.—The history of the Northern Herd is slightly more complicated. By the mid-1870s, the innovation and the advent of the flint hide market were all in place, but the boom in northern hunting did not occur until 1881. The reason for the delay seems to be the hostile Sioux nation.[39] The Sioux nation was the last significant Indian threat in the United States, and after the defeat of Custer in 1876 the US Army began an unrelenting campaign to eliminate this threat. It was only by the early 1880s that the remaining Sioux were either killed or settled peacefully on reservations. The legendary Crazy Horse surrendered in 1877, while the chief who defeated Custer—Sitting Bull—surrendered in 1881. During most of this period, hide hunting in the north was extremely dangerous. At virtually the same time, the Northern Pacific railroad made its way into Montana. This lowered transport costs and raised the price buffalo hunters could obtain for a kill.

In terms of our model, the change in hunter safety could be taken as an exogenous shift rightward in the distribution $F(\alpha)$. The new railroad would represent a small price shock, since transportation along the Missouri by steam ship was already an available and well used option. These two shocks work in much the same way as the initial tanning innovation. Therefore, while it is unclear what determined the exact timing of the Northern herd's slaughter, the model's assumptions combine to deliver excessive hunting, overshooting in hunter numbers, and a punctuated buffalo slaughter. These are important features of the northern slaughter.

III. Empirical Evidence

A natural consequence of the rapid and violent slaughter of the buffalo is that records of the number of buffalo killed are nonexistent. Existing academic work instead relies on a variety of sources to quantify the extent and timing of the kill. One common method starts with estimates of an initial stock of buffalo using carrying capacity estimates of the Great Plains and then finishes with the observation that by the late 1880s the number in the wild was estimated at less than 100. The difference between a mid-century population of perhaps 15 million and the final figure of 100 represents the slaughter. While this procedure is valuable in setting rough parameters for a more

[38] With a minimum viable population, the price shock can produce extinction as the outcome. A necessary condition for extinction is that the price shock drives the minimum huntable herd S_S below C_0. Extinction is, however, not a necessity, even in this case, because other interior steady states will exist if the kill function is relatively flat. In all cases, starting from an interior steady state, the price shock will create a boom in hide hunting via entry and a bust as the herd is reduced and hunters leave.

[39] At this time, the Sioux, Northern Cheyenne, and Northern Arapaho were not yet part of the reservation system. They were led by Chief Sitting Bull.

detailed accounting, it says little about the pace of the slaughter, its geographic location, or its ultimate cause.

An alternative approach is to employ data that are available on shipments of hides by the railroads operating in buffalo country and then amend these to take account for wastage prior to delivery. In the mid-1870s, Colonel Richard Irving Dodge contacted the three major railroads serving the main buffalo hunting areas. Dodge contacted the Atchison, Topeka, and Santa Fe, the Kansas Pacific, and the Union Pacific railroads asking for data on the shipments of buffalo products. Of these three, only the Atchison, Topeka, and Santa Fe (ATS) responded and provided figures of the number of hides shipped for 1872 (165,721), 1873 (251,443), and 1874 (42,289).[40] *It is important to note that these three numbers* (*one for each year*) *for hides shipped are the only data available on the number of buffalo killed in the Southern herd.* Additional numbers are often presented in secondary sources, but these additional data come from either extrapolations, estimated wastage adjustments, or author estimates of kills by natives, settlers, or the Army.

Dodge makes two adjustments to the shipping numbers. First, to correct for the nonresponse of the other two major railroads, Dodge multiplied ATS numbers by three, since he viewed the other two as equally likely to have shipped as many hides. Second, to account for the loss of killed or injured animals on the ground and the ruining of hides in skinning or transport, Dodge inflates individual year shipment data by a factor representing the ratio of buffalo killed to buffalo hides shipped. In the first years of the slaughter, waste was very high, and Dodge estimates that in 1871 every hide shipped represents five dead buffalo.[41] In 1872 this falls to three, and by 1873 one shipped hide represents two dead buffalo; finally, in 1874 there was very little waste, with one shipped hide representing one and a quarter dead buffalo. By these methods, Dodge arrives at the estimate of a little over three million buffalo killed from 1872–1874 on the Southern plains. Hornaday (1889) adds to Dodge's estimate a figure representing hunting by natives and settlers to arrive at an estimate of 3.7 million.

Estimates of the slaughter in the north are more tenuous. The northern shipping point was Fort Benton, located in northern Montana on the Missouri river, until the Northern Pacific Railroad hit Miles City on December 5, 1881.[42] Koucky reports the number of hides shipped in the peak years of 1881 and 1882 to be 270,000.[43] Hornaday estimated that the kill-off in the north must have been less than 1.5 million.

It is obvious from this account that very little is known with certainty about the magnitude and pace of the slaughter. Unfortunately, this is as true today as it was in 1889 when Hornaday lamented,[44]

> *Had there been a deliberate plan for the suppression of all statistics relating to the slaughter of buffalo in the United States, and what it yielded, the result could not have been more complete barrenness than exists today in*

[40] See Dodge (1877) for figures and his explanation for the railroads being less than forthcoming.

[41] Spoilage was a problem. Green hides collected by hunters soon rotted unless thoroughly dried or preserved in a lime solution to ship as wet hides.

[42] See "Steam Cars at Miles City," *New York Times*, December 18, 1881.

[43] Robinson (1995), however, presents larger estimates. 250,000 from a dealer H. F. Douglas, another 180,000 from Custer county, and an additional 200,000 hauled on the Northern Pacific.

[44] Hornaday (1889, p. 435).

> *regard to this subject. There is only one railway company which kept its books in such a manner as to show the kind and quantity of its business at the time. Excepting this, nothing is known definitely.*

Many observers lamented the sorry state of the plains at this time—the lines of putrid carcasses, the bone fields, and the large stacks of hides at railroad stations. From this evidence it is clear that a punctuated slaughter did occur, but its extent and exact timing are far less certain. Individual eyewitness accounts add colorful description but are not of much use in distinguishing between a slaughter of three million and one of ten million.

To examine the potential role of international trade it is of course natural to look at trade statistics, which until now have been ignored by researchers in this area. The benefit of trade statistics is that they often provide estimates of key physical and value flows when production data are known to be either incomplete or entirely absent. Governments had a strong incentive to record and meter the value and volume of materials entering and leaving their country, since import and export taxes were a major source of revenue at the time. Accordingly, trade statistics often tell a story where production statistics alone cannot. The same appears to be true here, with some caveats.

A. *Buffalo Hide Exports*

I employ a multistep procedure for identifying buffalo products in the international trade statistics. The procedure starts with the value of US hide exports from 1865 to 1886. To ensure that these are not reexports from Canada, Mexico, or other countries, I employ an exports from domestic production series.[45]

I start by converting hide values into hide numbers by deflating value figures for exports, using estimates of hide prices. Hide prices are provided inconsistently in the series. I generate a complete price series by taking individual estimates provided in the data and filling in the gaps using a price index for leather and leather products provided by George Warren and Frank Pearson (1933). The constructed price series is then checked against other individual price quotes found in the literature. For example, an additional source for price data is the series of Annual Reports of the New York Chamber of Commerce, which report prices for important items in the New York market.[46] One item consistently reported over this period is sole leather (hemlock tanned). This price series can be used in place of the Warren and Pearson index as a robustness check on my initial construction.

In Table 1 below, I present the series for hide prices developed using the Warren and Pearson price index and the alternative price series constructed using the price data drawn from the New York Chamber of Commerce reports. As shown, the New York hide price series differs very little from the main WP series, and all conclusions

[45] All US trade statistics are drawn from various years of *United States, Department of Treasury, Bureau of Statistics, Foreign Commerce and Navigation of the United States*. These are available online through the Archive of Americana, US Congressional Serial Set, 1817–1980, published by Readex, a division of Newsbank, Inc. at http://infoweb.newsbank.com/. While the data series I employ is labeled exports from domestic production, the western border between Canada and the United States was very porous in the nineteenth century. As such, I cannot rule out some US buffalo hide exports arising from kills in Southern Alberta. For a discussion of the links between Southern Alberta hunters and Montana merchants, see Henry C. Klassen (1994).

[46] See *State of New York Chamber of Commerce Annual Report*, Press of the Chamber of Commerce, 1865–1890.

TABLE 1—HIDE PRICES (DOLLAR/HIDE)

Year	WP	NY	HP	Year	WP	NY	HP
1866	4.56	4.74	0	1876	3.25	4.04	2.32
1867	4.12	4.82	0	1877	3.40	3.42	2.43
1868	3.93	4.43	0	1878	2.96	3.03	2.12
1869	4.18	4.66	0	1879	3.12	4.51	2.23
1870	3.99	4.51	0	1880	3.53	3.58	2.52
1871	3.93	4.35	2.81	1881	3.40	3.42	2.43
1872	4.06	4.35	2.90	1882	3.37	3.26	2.41
1873	4.12	4.35	2.94	1883	3.34	3.34	2.38
1874	3.99	4.20	2.85	1884	3.46	3.26	2.47
1875	3.84	3.89	2.74	1885	3.28	3.58	2.34

Notes: WP is hide prices found using the Warren and Pearson price index. NY is hide prices found using data drawn from the Annual Reports of the New York Chamber of Commerce. HP is the price-to-hunters series.

of the article are unaffected by my choice of price index. I have also included an estimate of the price a hunter may have received, assuming transportation and distribution account for 40 percent of the delivered hide price. Since hides were worthless until 1871, the price-to-hunters series starts at zero and then takes a jump upwards when the innovation hit.[47] While the two or three dollar jump in the value of a buffalo hide in 1871 seems relatively small to have such large effects, it should be remembered that a seasoned hunter could kill several thousand buffalo a season. Alternatively, he could earn perhaps \$50/month as a cattle hand. Even at these relatively low hide prices, the rents to hide hunting were huge.[48]

By using the WP hide price series I obtain a volume of hide export series shown in Figure 2 as the topmost line with the large bulge centered on 1875. The line labeled Total Hides starts from a low of less than 100,000 in 1867, peaks at a little over 1.2 million in 1875, then declines until it reaches 200,000 in 1880. In the early 1880s, exports cycle back upwards only to fall again in 1886. I will argue that the large bulge of exports in the mid-1870s represents the destruction of the Southern herd, while the smaller bulge in the early 1880s corresponds to the destruction of the Northern herd.

To eliminate cattle hides from the volume of hide export series I construct a measure of cattle slaughtered in the United States using a well known economic model of the cattle cycle. The US Agricultural Department publishes data from 1867 onwards on the number of cattle in the United States. I have graphed this data in Figure 2 as Cattle. Since the number of cattle in the United States in 1867 is approximately 25 million and is over 55 million in the late 1880s, the slowly rising line shown in the figure is graphed against the alternate right-hand-side axis which is measured in thousands of animals.

[47] All of the constructed price series exhibit a slight downward trend over time, and it is tempting, of course, to attribute this decline in hide prices to the additional supply created by the buffalo slaughter in the United States. While the slaughter could have an effect on world prices in theory, as an empirical matter this is unlikely (see Section VI).

[48] A typical hunting crew consisted of one shooter, two skinners, and a cook/look-out back at camp. A very good skinner could skin 30 bison per day, while a good hunter could kill 60 bison per day. If the crew actively hunted 25 days in a month then the monthly revenue from hunting is $25 \times 60 \times \$3.00/\text{hide} = \$4{,}500$. Assuming opportunity costs are \$50/month per person, for a total of \$200/month, this leaves a huge revenue stream of \$4,300/month to cover ammunition and defray the fixed cost of wagons, tools, etc.

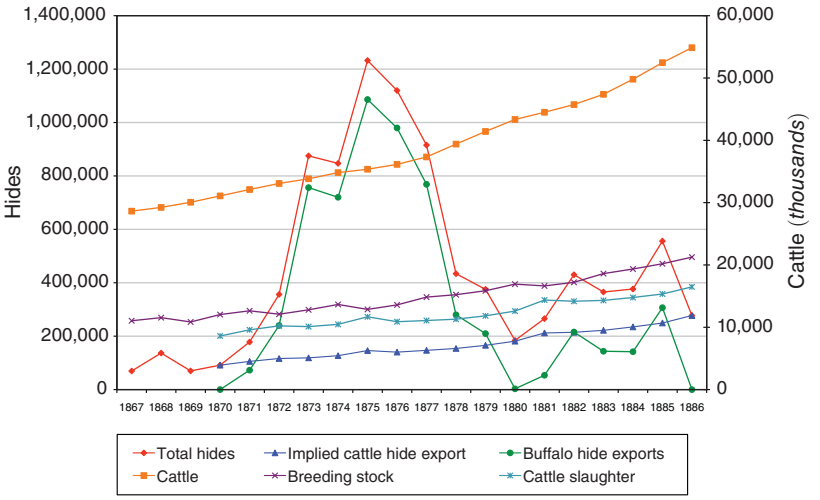

FIGURE 2. THE CONSTRUCTION OF BUFFALO HIDE EXPORTS

To move from cattle numbers to an estimate of the number of cattle hides exported, several steps are required.[49] First, I employ estimates drawn from Sherwin Rosen, Kevin M. Murphy, and Jose A. Scheinkman (1994) (hereafter, RMS) to generate an implied breeding stock from the overall cattle numbers. This step is necessary because not all cows are fertile, and not all cattle are cows. Using the implied breeding stock I then employ RMS's empirical estimates to generate an implied yearly slaughter. RMS develop a dynamic forward-looking model of cattle supply to study the cattle cycle in the United States and estimate their model on data starting in 1867. By employing their estimates I calculate both the breeding stock and the slaughter coming from the stock. The breeding stock and slaughter numbers are shown in Figure 2 and, given their magnitudes, both are graphed against the right-hand-side axis.

The final step in the identification of buffalo hide exports uses additional data from historical sources and makes one further assumption. Historical sources all agree that prior to 1870, there was no market in buffalo hides. Up to this point in time, buffalo was hunted for its robe, its meat, or amusement. Without knowledge of how to tan a buffalo hide, the hide market was nonexistent. This implies that in 1870, US exports of hides could only be those of cattle. Under this assumption, I find only 1 percent of the hides from slaughtered cattle are being exported in 1870. Similarly, historical accounts indicate that hunting on the northern plains stopped sometime during the 1883–84 season; shipment of hides down the Missouri by steamboat or via the Northern Pacific by rail may have ended sometime later, and exports later still because of potential inventory effects. Accordingly, I assume that in 1886, the export of hides must again represent only cattle. By 1886, I find 1.7 percent of the hides from slaughtered cattle are exported. Using these two points as anchors, I construct a linear interpolation for the years in between. Doing so

[49] See Appendix B of my working paper (Taylor 2007) for further details, and an alternative method that accounts for US hide imports, in addition to the US cattle slaughter, as part of domestic availability.

gives the light colored line representing an estimate of that part of the existing US cattle slaughter that represents exported hides. Subtracting the cattle hides exported from the overall export numbers gives an estimate of the number of buffalo hides exported from 1870 to 1886.

B. *Variation over Time and Regions*

The method of data construction is fairly lengthy and detailed. Were it not for the absolute paucity of other data on the number of buffalo killed or exported, and the existence of other confirming evidence that I will present, there would be little to suggest its acceptance. The series as constructed, however, has several desirable characteristics that argue in its favor.

First, note that by construction the series reaches zero in 1870 and 1886 (the two "identification points") but also approaches zero in 1880. 1879 was the last year of the Southern hunt; 1881 was the first year of a significant Northern hide hunt.[50] It is therefore comforting that our constructed series exhibits a pause as the hunt moved from south to north.

Further confirmation comes from other aspects of the series. Using the series, I calculate the implied number of buffalo hides exported during the entire 1871–1886 period. It sums to almost six million exported hides. Of the six million hides exported, five million hides come from what I am calling the 1870s destruction of the Southern herd and only one million from the destruction of the Northern herd. This is consistent with the accounts of Hornaday and many others indicating the Southern herd was much larger than the Northern. For example, Hornaday estimates a northern kill of only 1.5 million, whereas Figure 2 generates a total close to one million. Therefore the series generates a distribution across geographic region that roughly matches the historical account.

The total of five million killed in the south is, however, higher than that given in the estimates of Hornaday and Dodge, but both of these authors ignored the Southern herd destruction that occurred post-1874. This is not surprising. Dodge's book, *Plains of the Great West*, was first published in 1876; and Hornaday's account is that of Dodge since he states "I can do no better than to quote from Colonel Dodge almost in full."[51] Nevertheless, for the early years of the slaughter Dodge must be the best source, and he reports that in the "last year" of the Southern slaughter, 1874, the number of hides shipped by rail was only 126,000, falling from the peak of 750,000 the year before. New evidence on hide shipments I uncovered in the Annual Reports of the New York Chamber of Commerce for 1875–1876 show that 200,000 *bison hides* were shipped by rail to the port of New

[50] There are numerous first-person and contemporaneous newspaper accounts supporting these dates, although hunters left the Southern hunt and joined the Northern hunt at different times. Some hunters hunted only in Kansas and Nebraska and never went south to Texas; others hunted into Texas but left in 1876 or 1877, while still others continued to hunt until sometime in 1879. For a precise date we can use the *Frontier Times* article "The Last Buffalo Hunt Held in the Lone Star State," reprinted by the *Dallas Morning News*, August 9, 1925. The article dates the last hunt to November 1879. Various accounts from buffalo hunters tell of an active but dwindling hunt into 1879, and the interested reader is directed to Gilbert, Remiger, and Cunningham (2003) for these accounts. Two examples drawn from this source are that of Orlando A. "Brick" Bond, who recounts his last hunting trip in the Texas Panhandle in 1878; while John R. Cook places the last "big hunt" in the south in 1878.

[51] Hornaday (1889, p. 498).

York alone in that year.[52] This data strongly suggest that the Southern herd was not destroyed by 1874—a fact further corroborated by contemporary news stories and numerous personal accounts of buffalo hunters which make it clear that the Southern herd was not destroyed until 1879.[53]

If we consider the 1872–1874 period alone, my constructed series and Dodge's (constructed) numbers are much closer. For example, Dodge's estimate of hide shipments over the 1872–1874 period is approximately 1.4 million hides; the implied shipment of hides for export from Figure 2 is somewhat higher at 1.7 million. Therefore, the magnitude of the Southern herd destruction, and its pace in the early years of the slaughter, roughly match those available in the literature.

C. *Across Country and Across Hide Variation*

US export data show the value of hide exports to Germany being negligible in the 1860s, and then skyrocketing to over $100,000 in 1871–1872, rising further to over $500,000 in 1874, and then declining to $50,000 in 1880. It is striking that the sudden rise in exports of hides to Germany occurs just when other historical accounts place J. N. DuBois at center stage in the buffalo hide trade. The English data is equally striking. In the post–Civil War period, 1866–1870, US hide exports to England averaged $50,000/year. Starting in 1872, however, these exports took off, rising to over $2 million in 1873 and averaging over $1.3 million per year for the next six years. The sudden explosion in exports to England, together with the historical accounts of Lobenstein's activities, provides further corroboration.[54]

It may, however, be inappropriate to attribute the "explosion in exports to England," or the "sudden rise in exports to Germany," to the innovation. Exports to Europe may have risen for many reasons. The 1870s was a very tumultuous time in Europe, with German unification in 1870, the Franco-Prussian war in 1870–1871, and colonial expansion later in the decade. Perhaps the explosion in US hide exports to Europe reflects a temporary European event and not the buffalo slaughter. One immediate possibility we can rule out is changes in trade policy. Almost all of Europe allowed raw hides in tariff free or almost tariff free, but with higher tariffs in place for tanned hides and other leather products. The United Kingdom and France in particular had zero tariffs on raw hides throughout the entire period, and therefore, a perfectly timed trade liberalization in raw hides cannot be responsible.[55]

[52] The *Chamber of Commerce of New York 18th Annual Report* for 1875–1876 contains the throwaway line "Included in the receipts by railroad are about 200,000 bison hides," p. 115. Since rail was only one of many transportation routes, and New York only one of several large export ports, the total number of bison hides reaching the international market could have been much higher.

[53] For example, the *Fort Worth Democrat*, November 8, 1876, has a front page story titled "Freighters Wanted. The Largest Buffalo Hunt Ever Known." The story reports countless thousands of buffalo cover the prairies, while the hunt is the largest ever known.

[54] Country-specific destination of export data is provided in the United States. Foreign Commerce and Navigation series measured in US dollars.

[55] *The Tanners, Curriers and Leather Sellers Journal* ran a series of articles starting in 1871 giving the entire tariff schedule for hides, skins and leather products across Europe (see the December 1871, January–April 1872 issues). Very few countries placed any tariff on raw hides, or levied a small stamping duty. There are, however, many tariffs on finished or processed leather (i.e., tariff escalation was as prevalent then as it is today).

Ruling out a European Demand Shock or a US Supply Shock.—If a European specific demand shock is driving US hide exports upwards for reasons unrelated to the availability of buffalo, this shock should show up in European imports from other countries as well. To examine this possibility, I collected, where possible, hide import data from European countries that were major European destinations for US hide exports. The major destinations for US hide exports were France, Germany, and the United Kingdom. At present, I have collected this data from all countries except Germany.[56] Using this data, I examine how the share of hide imports coming from the United States varies over time. The rationale for using imports shares is simple: a uniform demand shock in Europe should raise its imports of hides from all sources, leaving the US share unchanged; a US-specific shock—such as the availability of buffalo hides—should, however, raise the share of imports coming from the United States dramatically and temporarily.

These new data also allow for a further sharpening of the hypothesis. The UK and French data allow me to divide their hide imports into tanned and raw hide categories; this is very fortunate since the available US export data makes no such distinction.[57] Since it is my contention that the buffalo hide exports to Europe were motivated by the inability of the US domestic industry to tan buffalo hides, increased buffalo hide exports coming from the United States must come in the raw hide category.

Another possibility is that the bulge in exports shown in Figure 2 represents a US supply shock unrelated to the buffalo slaughter. For example, a US- specific event such as the completion of railroads, the creation of an open range cattle industry, or the concentration of production in large slaughterhouses, could have raised US hide exports.[58]

To investigate this possibility I exploit one more feature of the data and one more piece of information regarding the innovation. The only non-European country receiving significant hide exports from the United States is Canada.[59] Since there is no evidence that industry in Canada was involved in the commercial tanning of buffalo hides, whereas the innovation was known in various European countries, I treat the innovation as a quasi-experiment with Canada as the control with no ability to tan buffalo hides, and the United Kingdom and France as treatment countries with the ability to tan.[60] Canada is not a perfect control: Canada was less developed than France or the United Kingdom in the 1870s, its distance from the US market is smaller, and it did contain buffalo (for discussion of the Canadian case see Section IV).

[56] For the France data see *France, Direction général des douanes, Tableau général du commerce de la France avec ses colonies et les puissance étrangères*, Renaud, Paris, published annually for the years 1825–1895. For the UK data see *Great Britain, Annual Statement of the Trade and Navigation of the United Kingdom with Foreign Countries and British Possessions*, for the years 1853–1870 and *Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions*, London, H.M.S.O. for the years 1871–1924. The German data are not up to the task, as hides are grouped in with fur items, and there is an incomplete record of imports across countries. I would like to thank Andy Strangeman and Investra Ltd. for their help in acquiring this data.

[57] The new data are useful in two other ways. The French data divide out large skins and hides from small and assures us that small skins from goat and deer were only 1–2 percent of total US hides and skins exports. The French and UK data also give hide imports in quantities.

[58] Any explanation along these lines does, however, have to explain why these US-specific events led to a *temporary*, and not permanent, rise in hide exports.

[59] For the Canadian data see *Canada, General Statement of Exports, Sessional Papers* 1860–1890.

[60] Canadian trade statistics do contain categories of exports tied to the buffalo (buffalo hair was one such item), but despite this practice of specifically labeling buffalo products there is no category for exported buffalo hides from Canada.

The United Kingdom and France are reliable treatment groups, if the assignment to treatment is exogenous. The *London Times* article, discussed previously, establishes that the timing of the innovation was exogenous to any characteristic of France or the United Kingdom, since these countries were not the intended market for the hides. The subsequent shipment of hides to the United Kingdom was likely determined by the sheer economic might of the United Kingdom at the time, the existence of other trading relations between the two nations, knowledge that the UK tanning industry was advanced, or even a common language. Shipments to Germany or France would be determined by similar factors. As a consequence, this assignment to treatment may well provide the exogenous variation we need to identify buffalo hides in the data.

The innovation was a necessary but not a sufficient condition for exports. The herds had to exist for exports to occur. I date the availability of the innovation at 1871, and as before assume the Southern herd was available until 1879. The Northern Herd was available to hide hunters in the early 1880s, when the threat from the Sioux was eliminated, and was destroyed by 1886. The most general specification would allow for two treatment effects (North and South), country-specific time trends, and country dummies as follows:

$$s_{it} = \alpha_i + \beta_i t + \gamma T^S_{it} + \delta T^N_{it} + \epsilon_{it}, \tag{2}$$

where s_{it} is the US share of raw hide imports in total raw hide imports into country $i = \{France, UK, Canada\}$ in year t from 1866 to 1887; α_i is a country-specific constant, and $\beta_i t$ is a country-specific time trend. T^S_{it} is the treatment effect which takes on the value 1 during 1872–1879 and is zero otherwise; T^N_{it} takes on the value 1 from 1881 to 1886 and is zero otherwise.[61]

Table 2 presents results from estimating, via OLS, various specifications of equation (2). In the first column, I restrict the sample to the import share data from the United Kingdom and France. In this column, I am testing whether the US mean import share into these markets varies systematically with the slaughter time periods. In doing so, I allow for the possibility the US share is growing over time or varies across countries. The results in column (1) indicate a strong and significant increase in US import shares in these markets during the Southern slaughter, and a smaller but not statistically significant increase during the Northern herd kill-off. Outside the treatment periods, the US share in these markets is indistinguishable from zero. I take these results as evidence against a uniform demand shock in Europe being responsible for the rise in US hide exports.

In the remaining columns, I expand the sample to include the US share of hide imports into Canada. As we move from column (2) rightwards in the table, more restricted versions of equation (2) are estimated. It is apparent from the results in columns (2) and (3) that we cannot distinguish between the constants for the

[61] Over the period 1866 to 1887, the mean raw hide import share into France was 2.9 percent with a standard deviation of 3.3 percent, the mean raw hide import share into the United Kingdom was 3.3 percent with a standard deviation of 3.9 percent, and the mean raw hide import share into Canada was 91.5 percent with a standard deviation of 6.6 percent.

TABLE 2—A QUASI EXPERIMENT

Dependent variable. s_{it} $i = \{Canada, France, UK\}$	(1)	(2)	(3)	(4)	(5)	(6)
France intercept	−0.33	−0.33	0.24			
	(0.89)	(0.89)	(0.67)			
UK intercept	1.24	1.24	0.67			
	(0.85)	(0.85)	(0.84)			
Europe intercept				0.46	0.47	0.60
				(0.41)	(0.67)	(0.78)
Canada intercept		91.12***	91.12***	91.12***	91.08***	90.73***
		(2.99)	(2.96)	(2.94)	(2.09)	(1.86)
France time	− 0.08	0.09				
	(0.06)	(0.07)				
UK time	−0.01	−0.01				
	(0.07)	(0.07)				
Europe time			0.04	0.03		
			(0.05)	(0.05)		
Canada time		0.03	0.03	0.03		
		(0.18)	(0.17)	(0.17)		
Time					0.04	0.07
					(.09)	(.06)
North treatment	1.07	1.07	1.07	1.07	1.10	
	(0.71)	(0.71)	(0.67)	(0.67)	(1.05)	
South treatment	4.80***	4.80***	4.80***	4.80***	4.81***	4.38***
	(1.10)	(1.10)	(1.08)	(1.09)	(1.09)	(1.07)
Adjusted R^2	0.65	0.99	0.99	0.99	0.99	0.99
RMSE	3.03	4.67	4.63	4.60	4.56	4.53
Observations	44	66	66	66	66	66

Note: Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

United Kingdom and France, and, hence, from column (4) forward they are grouped together under the heading Europe. The constant terms for Europe and Canada are, however, very different. Over 90 percent of raw hides imported into Canada come from the United States, whereas, outside of the treatment period, the US market share in Europe is estimated to be close to zero at 0.5 percent. This difference is not surprising given the proximity of the United States to Canada. There is also little evidence of time trends in the data. A common to Europe trend is imposed in column (3), while a common to all countries trend is introduced in column (5). The regressions' high level of fit comes from features of the data. Most of the variation in the data is cross-country; therefore, country-specific constants alone capture much of the variation. Despite this, both treatment effects are positive, but only the Southern treatment is statistically significant.

The relative and absolute magnitudes of the treatment effects also bear scrutiny. The Southern treatment effect is estimated to be four to five times larger than the Northern, which is consistent with the historical accounts of the relative size of the Northern and Southern slaughters. The absolute magnitude of the Southern treatment effect is estimated at close to 5 percent points. Therefore the Southern treatment effect represents a very large tenfold increase in the share of raw hides coming from the United States.

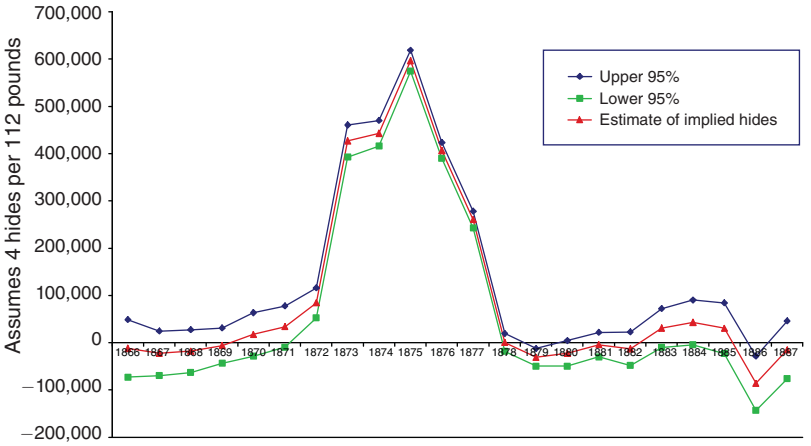

FIGURE 3. IMPLIED BUFFALO HIDE IMPORTS INTO THE UNITED KINGDOM

One final means of evaluating these results is to employ them to construct a measure of implied buffalo hide shipments from the United States to the United Kingdom and France. I calculate counterfactual imports into the United Kingdom and France under the assumption that the innovation did not arrive in these countries. To do so, I employ the estimates from column 6 and set the treatment effects to zero to obtain a predicted import share for each country together with their 95 percent confidence intervals. Multiplying these predicted import shares by actual imports generates a counterfactual import volume. Subtracting counterfactual from actual imports gives an estimate of the buffalo hides imported. Figure 3 presents the mean estimate for the UK together with an upper and lower estimate generated when I employ the lower and upper 95 percent confidence interval for the predicted import share in the calculations.[62]

This figure is striking. The implied buffalo hide imports into the United Kingdom is predicted to be either very small or negative until the early 1870s. This is as it should be since buffalo hide imports must be zero prior to the innovation. Post-innovation, imports rise dramatically until 1875, only to fall again in the late 1870s. The figure shows what may be a small Northern herd impact in the early 1880s that falls off in 1886. Simply adding the implied hide imports for the United Kingdom and France in 1875 shows imports of over 1 million buffalo hides, which is consistent with aggregate US exports for 1875 presented in Figure 2. Summing the implied hide imports over the entire period (including the negative elements for both the United Kingdom and France) yields imports to Europe of more than 3.5 million

[62] The corresponding figure for France is available in the online Appendix. In constructing the figures, two additional assumptions are made, and one caveat is in order. First, since UK and French imports are in terms of weight, I have to translate hundredweights and kilograms of hides into buffalo hide numbers. I assume a hide weighs 28 lbs (then there are 4 in an English hundredweight), which is a conservative estimate given my reading of the history. Second, I have assumed the overall quantity of hide imports into the United Kingdom and France would have remained the same absent the innovation. I think this is reasonable. Recall that the United States was only a small provider to these countries, their aggregate demand for hides was set by a derived demand for leather which should be independent of the innovation, and the hide market worldwide was huge, and, hence, hide prices would not be affected by the absence or presence of US buffalo hides. Finally, the reader should note that the upper and lower estimates presented in the figures are not confidence intervals for the implied buffalo hide exports.

buffalo. If we account for waste using Dodge's estimates of wastage, the implied kill would be larger still.[63]

Overall, the examination of the across country and across hide variation in the data supports my earlier conclusions. The increase in raw hide imports from the United States during the time of the Southern herd destruction is a European/US-specific event. Despite the fact that the data used are different, the method of identifying buffalo hides is different, and the variable under study is different (import shares of raw hides versus export levels of all hides), the results are remarkably similar to those presented earlier. There is strong evidence that the tanning innovation led to an unusual and temporary level of raw hide imports into the United Kingdom and France, but not Canada. It appears that this surge did not occur because of a broad-based demand shock in Europe, nor because of a supply shock to cattle production in the United States. While alternative explanations for this data remain, the set of credible alternatives has been narrowed considerably.

IV. Alternative Hypotheses

Given the importance of the buffalo to Native and Western history and its role as a national symbol, it should come as no surprise that there are numerous explanations for the buffalo's demise. The slaughter has been linked to the arrival of the railroads, native overhunting, US Army policy, hide hunting, and environmental change. Research contains numerous book-length treatments, hundreds of scholarly articles, and many theses and dissertations. While many of these hypotheses have reasonable premises, are logically consistent, and fit aspects of the historical record very well, none of them has been able to provide confirming evidence from the subject under study—the buffalo slaughter.

A. *The Army and Federal Government*

Many accounts of the buffalo slaughter hold the US federal government responsible. Its role in the slaughter is sometimes explicit—as when authors argue the elimination of the buffalo was a secret goal of government policy; or merely complicit, by turning a blind eye to the slaughter hoping it would solve the Indian problem. Evidence for an explicit role is difficult to come by. No secret orders to eliminate the buffalo have ever been found, and estimates of the kill by US Army soldiers are, at best, incomplete. For example, David D. Smitts (1994) presents a case for an explicit policy of elimination transmitted via secret orders and buttresses his case by documenting numerous accounts of wasteful killing by soldiers. These accounts, however, are just that, individual accounts of killing tens or hundreds of buffalo at a time, and not slaughters of hundreds of thousands or millions.

The evidence provided for government complicity is much stronger. The evidence for this hypothesis combines the many failed and stalled bills introduced in Congress, with several quotes from government officials noting the salutary effect

[63] The implied imports of hides differ slightly from those I presented in Figure 4 of my NBER working paper (Taylor 2007). There I use the deflated US export series to create the counterfactual; here I use the country-specific import data. The figures tell the same story.

an extinction would have on domiciling the natives, to then conclude that inaction was a deliberate choice by the Grant Administration. For example, a bill restricting the harvest of female cattle to only Indian hunters on all federal lands passed both the House and the Senate in June of 1874 but was killed by a pocket veto by President Grant. This result is perhaps not surprising, since Grant's Secretary of the Interior, Columbus Delano, was in favor of the destruction of the buffalo. He refused to stop hide hunters from entering Sioux lands, and in his report for 1873 wrote, "I would not seriously regret the total disappearance of the buffalo from our western prairies, in its effect upon the Indians. I would regard it rather as a means of hastening their sense of dependence upon the products of the soil and their own labors" (Gard 1960, p. 207). Similar sentiments are found in speeches made by Generals Sherman, Sheridan, and Custer, who clearly thought the destruction of the herds would have a beneficial effect in reducing Indian resistance.

We can add to this evidence the fact that the federal government was regulating some resources well. For example, the seal fishery on the Pribilof islands in Alaska was regulated with a quota holding harvests to 100,000 animals per year.[64] This suggests that resource policy was not unknown to the government. If we ignore the opportunity cost of western land, then the first-best solution is a simple harvest tax or quota on the kill (with, perhaps, an allowance for age-, sex-, and season-specific prohibitions). The Great Plains is, however, an incredibly large area that was only sparsely populated over much of the relevant time period. Therefore, successfully implementing such a policy seems unlikely.[65] If, however, as it appears, almost all the product was destined for the export market, then an export tax would be equally efficient. This tax could have been applied at major collection points for exports (New Orleans, New York, Boston, etc.), and experts in the hide business could have been employed to distinguish cattle from bison hides to limit disguised exports.

Unfortunately, very little was known at the time about the slaughter (recall Hornaday's lament), and this may have slowed action. The Administration and Congress already had their hands full with reconstruction efforts, Indian wars, the Panic of 1873, and the passage of a new Civil Rights Act. Therefore, while it is difficult to tell whether inaction was politically motivated or driven by ignorance, it should be clear that the lack of federal legislation was key to the pace and scale of the slaughter. It is also difficult to argue inaction was optimal.[66]

[64] In 1877, Congress granted a 20-year lease to the Alaska Commercial Company requiring an annual payment of $55,000, a $2.00 per skin royalty, and a variety of other conditions related to the islands' Aleut inhabitants. See Patterson and Wilen (1977).

[65] The regulatory problem was well known. In 1866, a *Harper's Magazine* writer commenting on the introduction of a bill to restrict buffalo hunting noted that "The difficulty will be to secure its enforcement, as the extermination of these animals, which is now impending, is brought about by parties who, at a distance from any control, are a law unto themselves, and who are not likely to be influenced by any enactments that do not involve the means of execution" (*Harper's Magazine*, April 15th, 1866, Scientific Intelligence section).

[66] Given bison's fast rate of reproduction, their location on many marginal western lands not suitable for the then ubiquitous Texas Longhorns, and the speed and waste with which the kill occurred, it is difficult to argue the slaughter was in any sense an optimal solution to this particular resource management problem.

B. *The Railroads*

Another often mentioned hypothesis is that the railroads killed the buffalo. The railroads did promote buffalo hunting excursions to eastern hunters and allowed shooting from rail cars when buffalo were present. More importantly, the railroads were an important transportation link in the buffalo hide trade. For example, Dodge's reply from the Atchison, Topeka and Santa Fe indicates shipments of almost 460,000 hides on this line from 1872 to 1874. My own research uncovered an additional 200,000 hides shipped in 1875–1876 to the New York hide market. Additional shipments in later years and on other lines surely occurred, but how large they were is unknown. Arguing against a pivotal role for the railroads is shipment data on hides brought to the New York market in the mid- to late 1870s. These data indicate only a relatively small share of hides were carried by the railroads (22.8 percent), with the remainder brought by boat and steamer.[67]

Even if the railroads transported the bulk of the hides, it is difficult to argue they played more than a supporting role in the Southern slaughter. For example, the Union Pacific line cut across the Platte River valley to reach Cheyenne, Wyoming in 1867. This rail line effectively cut the existing bison herd in two, and made the shipment of bison hides on rail very easy *four or five years prior* to the slaughter.[68] In 1870, the Kansas Pacific ran through Kansas, reaching Kit Carson, Colorado in March 1870 and Denver in August of that year—again, before the slaughter began. Much has been made of the fact that the Atchison, Topeka and Santa Fe reached Dodge City in September of 1872, right in the midst of the boom; however, given the pace of railroad construction crossing the Midwest at this time it would be surprising not to find at least one contemporaneous station completion during the hide boom. From all accounts Dodge City did become an important hide town, but this does not imply it created the boom.

In the North, there is no gap in time between the completion of the Northern Pacific into Montana and the slaughter of the Northern herd. In this case, the arrival of the railroad may have been critical, but this is not entirely clear. Prior to and after the railroad's arrival, goods came and went by river boat on the Missouri when it was clear of ice. While the railroad may have lowered transportation costs, this region had other transportation options. It seems likely in fact that the northern slaughter was delayed by the hostile Sioux Indians, and not any lack of transportation. It was not until the early 1880s that the northern buffalo range was made safe for buffalo hunters—and made safe for the Northern Pacific to complete its construction into Montana.[69]

[67] Evidence on the modes of transportation used for hides is reported in Ellsworth (1971). His Table 20 shows railroads carried only 22.8 percent of the hides delivered to the New York hide market from 1876–1879. In fact, this share was the greatest contribution by the railroads over the entire 1857–1889 period. Coastal, plus canal and river, transport carried the majority of hides.

[68] This point is also made by Lueck (2002).

[69] Some of these events are closely linked. For example, Smitts (1994) argues that the US Army helped push the Northern Pacific into Montana as a means to remove the Northern herd and therefore starve Sitting Bull into submission.

C. *Environmental Change and Native Overhunting*

Two other explanations are environmental change coupled, perhaps, with native overhunting. The Great Plains experienced a very wet period up to the early 1850s and had a series of serious droughts in the subsequent 30 years. Some authors contend that these environmental changes reduced buffalo numbers considerably prior to 1870. If we add to these stresses native overhunting created by the robe market and the breakdown of societal norms, we obtain a large reduction in buffalo numbers prior to the hide hunters.

The evidence presented earlier is largely at odds with this explanation. The buffalo slaughter was large and not small, and while it is possible the herds were larger in 1850 than at the start of hide hunting in the 1870s, it is clear that the slaughter during the 1870s and 1880s was spectacular in its magnitude. Environmental change may have contributed to an overall lessening of buffalo numbers, but had it not occurred I suspect hide hunting would have just lasted longer.

Native overhunting may well have played a significant role. Lueck (2002), for example, suggests the unrelenting pressure of the US Army and settlers led to the abandonment of common property resource management by natives, giving way to open access and excessive hunting. How important this force may have been relative to hide hunting is difficult to assess, but native overhunting has been implicated in the Canadian case. Starting in the early part of the nineteenth century, the Canadian Metis population near present-day Winnipeg organized hunts from the Red River Region that took thousands of buffalo yearly.[70] These hunts started in the 1820s and grew over time, sweeping Manitoba, southern Saskatchewan, and parts of the northern US border states clean of buffalo.

To these annual hunts by the Metis has to be added a very considerable provisioning demand from the Hudson's Bay Company for pemmican (a combination of dried fruit, fat, and buffalo meat that could be stored for long periods) to feed their agents in the field and boat crews bringing furs upstream to ports on the Hudson Bay.[71]

Native hunting for subsistence, hunting in winter months for the robe trade, and hunting in the summer months for the provisioning trade destroyed the relatively small Canadian herd by 1879. Importantly, the Plains bison were eliminated in Canada well before American hide hunters moved north to eliminate the herds left in Montana.[72] The Canadian case is therefore quite different but argues against dismissing the impact of native hunting at least over extended periods.

Missing from the discussion in this literature is a recognition that for any renewable resource, a reduction in the resource size often raises the sustainable yield by relaxing environmental constraints. For example, a herd at its carrying capacity of 15 million can sustain a harvest of zero by definition; but if 7.5 million are removed

[70] The Metis are individuals with mixed European and Native American parentage.

[71] Arthur J. Ray (1984) and George Colpitts (2010) both report that in 1860s, the Hudson's Bay Company's yearly demand for pemmican exceeded 100 tons, with both natives and Metis working to satisfy this demand. Ray estimates that demand for pemmican, robes, and subsistence by the Metis and native populations may have taken over 300,000 buffalo per year.

[72] Friesen (1988), William A. Drabek (1996), and John E. Foster (1992) all attribute the Canadian kill off to Metis and native hunters meeting both the demand for robes and provisioning needs of the Hudson's Bay Company. See Drabek for estimates of the provisioning demand of the HBC, and Friesen for estimates of fur exports to the US and the UK from the Canadian prairies.

it can sustain a harvest of 750,000 per annum. This suggests that even entirely wasteful killing of thousands of buffalo by natives, by settlers, and by the Army may have raised the sustainability of larger harvests and not lowered them. But if these killings were, in total, large and taxed the herds quite heavily prior to the 1870s, then these additional pressures may have played a role in the speed and completeness of the slaughter by hide hunters.

V. Substitutability, Size, and World Trade

A. *The World Hide Market*

The analysis I've presented has focused almost exclusively on the events in the United States. These events, however, occurred against the backdrop provided by the world hide market, and implicit in my analysis are several assumptions regarding its workings. The first is that cattle hide and buffalo hide are perfect substitutes after adjusting for quality (as, for example, given by weight or thickness). The existence of a "world hide market" already assumes hides from various countries in the world were close enough substitutes to make a meaningful aggregate, but the world supply of hides came from various South American countries, Asia, Africa, Europe, and the United States; from different breeds of cattle; and from cattle raised in very different conditions. Hides themselves were of varying qualities, and were perhaps good, but imperfect, substitutes. Apart from differences across shipments, countries or types, the major difference across hides was in their categorization as either heavy or light. Heavy hides (like the buffalo, most cattle, and oxen) were used primarily for boot and shoe sole leather, harness equipment for horses, and for industrial belting. Light hides, together with skins taken from deer, calves, sheep, and other small animals, featured in leather uppers, gloves, and other accoutrements requiring flexibility in wear.

Formal tests examining the degree of substitutability across hide types is virtually impossible because there is very little useful data on the price of buffalo hides. Hide prices quoted in the literature differ by year, location, hide category (bull, cow, calf) and presumably quality. I have, however, been able to obtain the price of hemlock-tanned sole leather produced using buffalo hides and 15 other common hides.[73] If tanning costs are either constant across time or perfectly correlated across hide types, then variation in these prices of tanned sole leather give us some idea of how closely the underlying hide prices varied—and their substitutability. An analysis of this data, available for only 36 months in 1878–1880, suggests the various hides were indeed very good substitutes. For example, the average correlation in prices between bison (sole leather) and other cattle hide types is 0.87. A simple augmented Dickey-Fuller test shows that the price of bison sole leather is cointegrated with the sole leather prices for Buenos Ayres Middle, Buenos Ayres Heavy, California Middle, Oak Slaughter Backs Light, Oak Slaughter Backs

[73] See *New York Chamber of Commerce Annual Reports, Annual Review of the Hide Trade* for 1877, 1878, and 1879. The types listed in addition to bison are: Buenos Ayres Light, Buenos Ayres Middle, Buenos Ayres Heavy, California Light, California Middle, California Heavy, Common Hide Light, Common Hide Middle, Common Hide Heavy, Oak Slaughter Backs Light, Oak Slaughter Backs Middle, Oak Slaughter Backs Heavy, Union Crop Light, Union Crop Middle, and Union Bellies.

Middle, Union Crop Middle, and Union Crop Bellies.[74] This evidence plus my reading of the literature suggests buffalo hide and other heavy hides were very good substitutes for one another.

Even if buffalo hides were good substitutes for others in the market, a second assumption is the smallness of this new buffalo supply relative to the total number of hides transacted in world markets. I have already presented evidence suggesting that in the peak year, 1875, the United States may have exported over one million buffalo hides. In other years the totals are less and often far less. One million buffalo hides, however, accounts for a small fraction of the world hide market. For example, the annual US cattle slaughter would have produced approximately 10 million hides in 1875.[75] Estimates of the world hide market itself—including all European and South American countries—are available for 1880, and this data indicates a market value of 115 million dollars in exports.[76] Dividing this export value by the average WP hide price taken from Table 1 of $3.53/hide in 1880, implies world exports are on the order of 33 million hides. Therefore, even in the peak year of 1875, buffalo hides must have been only 3–4 percent of the total world hide exports.

B. *The Role of International Trade*

The slaughter is not a unique example of resource overuse created by burgeoning demand and poor regulation. It may, however, be unique in its scale, its speed, and the critical role played by international markets. International markets played two roles. First, although some US tanners may have learned to tan buffalo hides by the late 1870s, the destruction of the Southern herd and the creation of the flint hide market would not have occurred absent the technical ability to tan buffalo in Europe. Therefore, advanced foreign technology brought to bear on local markets by the vehicle of international trade created the flint hide market. But even if the technology was transferred to the United States, or US tanners gained this ability much sooner than I suspect, there remains a second and perhaps more important role for world markets—limiting price adjustment.

Although the bison slaughter was a major event in US history, it was a minor event on the world stage. And being small on world markets meant that some of the typical insulating and signaling properties provided by a market price system were missing. In the trade and environment literature several authors have examined how world prices, which are less responsive to domestic disturbances, may increase the likelihood of extreme outcomes (Copeland and Taylor 1999), or alter the incentives for environmental policy (Carol McAusland 2003, 2008). In these contributions, international

[74] Seven of the 16 hide types are integrated of order one, as is bison. These hides are all cointegrated with bison using a simple Engle-Granger augmented Dickey-Fuller test. The remaining hides are integrated of order two. See online Appendix for full results.

[75] This is based on the simulation presented in Figure 2.

[76] For information on the magnitude of the world hide market see John R. Hanson (1980), *Trade in Transition: Exports from the Third World*, 1840–1900; datasets are available online at http://eh.net/databases/developing. Hanner presents estimates of hide exports for less and developed countries for the years 1840, 1860, 1880, and 1890. These figures are in US dollars but do not include the United States as an exporter. Using US export data from Foreign Commerce and Navigation I calculate that the US share of "world" hide exports is 0.7 percent in 1840, 2.9 percent in 1860, 0.53 percent in 1880, and 0.52 percent in 1890. Overall exports in 1860 were 34.4 million and 111.5 million in 1880. In even the largest single year of the slaughter, 1875, estimated US bison exports would only account for 3 or 4 percent of a 100 million-dollar market.

trade, even at autarky prices, can have real effects. It does so by altering either the incidence of environmental regulation—for example, in the bison case an export tax would be born entirely by the domestic hide hunters—and therefore its political costs; or by making outcomes with extreme specialization more likely because consumption demands can be met by imports. For example, as the slaughter progressed and hide supplies in the United States rose, world prices held firm, and this maintained the incentive to hunt. Over time, as bison numbers fell, prices again did not adjust to signal rising scarcity.[77] State governments, the federal government, or private agents might have moved quicker had prices risen tremendously. Therefore, it appears that unresponsive hide prices maintained the economic incentive for the slaughter, masked any signs of rising scarcity, and perhaps raised the domestic costs of policy.

VI. Conclusions

The purpose of this article was to investigate the slaughter of the plains buffalo in the nineteenth century using a combination of theory, empirics, and firsthand accounts of buffalo hunters. I have presented an explanation for the slaughter that is not conventional. While the US Army, native overhunting, and the railroads are typically held responsible for the slaughter, the role of international trade has featured minimally, if at all. Instead, I have argued that free trade in buffalo hides was critical to the explosion of activity on the plains in the 1870s. By employing insights from theory, I have pieced together statistical evidence from numerous countries, diary and newspaper accounts, and logic to present a largely circumstantial, but hopefully compelling, case that the plains buffalo was not eliminated by the usual suspects—it was instead the victim of global markets, technological progress, and government policy failure.

The introduction to this article claimed that (i) a price for buffalo products that was largely invariant to changes in supply; (ii) open access conditions with no regulation of the buffalo kill; and (iii) a newly invented tanning process that made buffalo hides into valuable commercial leather were jointly necessary and sufficient for the slaughter on the Great Plains. The theoretical results demonstrate that the combination of a tanning innovation, open access to buffalo herds, and fixed world prices delivers a punctuated slaughter matching that witnessed on the Great Plains. I take this as proof of sufficiency.

I have also argued that the slaughter can be generated only when demand is very elastic. This establishes the necessity of a market price that is "largely invariant" to changes in supply. The tanning innovation was proven to be necessary by the absence of the slaughter during the five years prior to 1872, when the Union Pacific had reached the heart of buffalo country. And the necessity of open access for the slaughter is proven by numerous private parties who found buffalo to be such a valuable resource that they established property rights on their own by capturing and then breeding live buffalo. Several entrepreneurial ranchers in the 1870s and 1880s established private herds that, until federal legislation arrived in the mid-1890s, probably saved the buffalo from extinction.

[77] Some bison products did rise in price as the kill-off continued, but theses were for unique bison products. For example, Robert F. Beal, Foster, and Louise Zuk (1987) reports robe prices in Canada rising in the mid- to late 1870s; Lueck (2002, Table 3) reports bison trophies and robes rose in price during the Northern slaughter.

Many developing countries in the world today are heavily reliant on resource exports, are struggling with active or recently past civil wars, and few, if any, have stringent regulations governing resource use. The Slaughter on the Plains tells us that putting development before environmental protection can be a risky proposition: in just a few short years, international markets and demand from high income countries can destroy resources that otherwise would have taken decades to deplete.

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