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The Integration of Blockchain Technology to the Beef Industry – A Comparative Analysis

Abstract

This paper seeks to explore the different plausible and implemented applications of blockchain technology in the beef industry in two representative markets: The United States and Kenya. Previous papers discuss implementation of blockchain to the beef industry, without a focus on the variations between beef industries and supply chains in various countries, a gap this paper aims to address. The main method of research has been primary, traveling to these countries and engaging in conversations with various stakeholders about their industry's supply chain and the problems and opportunities therein. Overall this paper finds that the integration of blockchain to the beef industry is broadly advisable, but that the most pragmatic and achievable uses and means of blockchain integration vary widely based on the stage of development and regulatory environment of different country's beef industries.

Keywords

blockchain, beef industry, cattle industry, supply chain optimization, supply chain transparency, meat industry, food traceability, ranching, agribusiness

Disciplines

Agribusiness | Agricultural and Resource Economics | Agricultural Economics | Beef Science | Business | E-Commerce | Food Processing | Food Security | Food Studies | Meat Science | Operations and Supply Chain Management | Technology and Innovation

The Integration of Blockchain Technology to the Beef Industry – A Comparative Analysis

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The Wharton School

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Introduction:

Importance of the Topic

The global beef industry is incredibly varied across geographies, regulatory environments, and according to development of peripheral industries. As a consequence, the supply chain of the beef industry is also incredibly complex, with numerous participants and regulators involved in the process to ensure food safety as well as accurate labeling and identification. However, the complexity of the supply chain creates opacity of pricing and of the product's origins and quality, reducing the bargaining power of the main producers of beef and also inhibiting customer's ability to accurately discern the quality and origins of the meat.

While beef industries in more developed countries have overcome a considerable amount of the complexities of the supply chain through advanced regulatory systems, inefficiencies still exist. Most notably, in developed countries there is a decoupling of customer's higher willingness to pay for specialty or higher quality beef, and the actual payout to smaller ranchers who want to address this particular part of the market. In developing countries with less rigorous regulations, a main concern for the beef supply chain is in food safety and traceability.¹ However, even in developing countries there may be a more niche domestic or export market that is also interested in specialty or higher quality beef as well.

Research Goal

With the development and increased use of blockchain technology, there are numerous and significant opportunities to integrate blockchain to the beef industry in a variety of ways. What this paper aims to address is how the various opportunities of blockchain technology integration in the beef industry may change for beef industries in differing stages of development.

Understanding these opportunities for the integration of blockchain technology in the beef industry leads to the potential for significant positive social impact as well. Positive social impacts related to the beef industry can include increased food safety, decreased food costs, increased earnings for smaller producers, economic expansion for developed and developing countries, increased international trade, improved livestock living conditions, and greater market access to beef, among others.

To accomplish this research goal, I endeavored to understand the potential and implemented applications of blockchain technologies in the beef industry and to analyze the positive social

¹ Alarcon, Pablo, et al. "Mapping of Beef, Sheep and Goat Food Systems in Nairobi — A Framework for Policy Making and the Identification of Structural Vulnerabilities and Deficiencies." *Agricultural Systems*, vol. 152, 2017, pp. 1-17

and economic impact that such applications could bring to both producers of cattle/beef as well as consumers and other economic participants. For pragmatic reasons the United States and Kenya were chosen to be the representative samples of countries with a highly developed and a largely developing beef industry, respectively. As a consequence of this paper mainly researching the potential applications of blockchain integration, the majority of the research conducted consists of primary interviews with various participants in each location, as well as including my direct observations of the conditions and potential applications throughout my site visits. The paper is also supplemented by other literature and data on the subject.

Naturally, some limitations to this research existed. Due to the recentness of blockchain technology there are limited cases of it being applied to the beef industry specifically, and most of the current initiatives are in their earliest stages. Additionally, the data is limited and often private in regarding some of the specifics of the beef industry as related to this paper. Finally, a majority of the interviews conducted were not taped and interviews conducted in Kenya specifically had significant language barriers or were conducted through my guide, leading to the possibility of some inaccuracies in their recording.

Outline

This paper is structured in the following way. The first section will focus on blockchain technology. A brief overview of the history and functionality of the technology will be given, followed by a more in-depth discussion of the specific applications of blockchain are pertinent to the beef industry. The second section will focus on the beef industry. A brief general overview of the beef industry will be followed by the more detailed accounts of the beef industries of Kenya and the United States. Within the discussion of each country's industry the possible future and any current applications of blockchain will be discussed. The third section will collate the findings from the research, offer recommendations for public and private entities in relation to blockchain integration in the beef industry, and offer concluding remarks in relation to the research.

Blockchain

Blockchain is a relatively new and exciting technology that promises to bring great change to a variety of industries and operations. This paper hopes to provide a comparative analysis of the possible benefits of blockchain integration to the beef industry in Kenya and the US. While blockchain is the specific technology that is being examined in this paper, the key focus will remain on the respective countries' beef supply chains and industries, and the possible benefits derived by blockchain integration.

This section aims to give a very brief overview of blockchain technology, the various applications of blockchain that are relevant to the beef industry, and the limitations and restrictions that blockchain integration may face.

Overview and History

To start, blockchain is defined by Meriam Webster dictionary as “a digital database containing information (such as records of financial transactions) that can be simultaneously used and shared within a large decentralized, publicly accessible network, *also*: the technology used to create such a database”². While this definition overlooks much of the technical aspect of blockchain, it encompasses the main focus of blockchain as being a decentralized, publicly accessible method of record keeping. Important to note, verifying and allowing new information on the blockchain is consensus driven, meaning that information added is immutable and resistant to hacking.

As Wharton Professor Kevin Werbach writes, the function of blockchain is “to reliably share information among parties who may not trust one another. In other words, everyone can have his or her own copy of a ledger and trust that those copies remain the same, even without and central administrator or master version.”³ This function is widely applicable and naturally many different industries and areas are trying to find how this functionality can improve their systems. This application first started with cryptocurrencies.

Various Applications of Blockchain Technology

On January 3rd, 2009 someone (or a group) under the alias Satoshi Nakamoto launched Bitcoin. Central to the functionality of cryptocurrency, blockchain was introduced to the world and proved its pragmatic ability to transfer assets through a decentralized system. Although blockchain began as the infrastructure of cryptocurrencies, many others soon found its applicability extends beyond cryptocurrencies.

While there are scores of implemented, proposed, and theoretical applications of blockchain in relation to the beef industry there are two main uses have been mentioned in various interviews and articles.

The first, and much more complex and theoretical idea is to use blockchain as an executor of “smart contracts” and even tie in cryptocurrencies to facilitate direct transactions. Without elaborating on the technological aspects, the concept is to encode a set of parameters that when met automatically execute a given set of instructions, such as a transfer of assets or sale. In beef, this could mean that each cow is “tokenized”, and it can be bought and sold on an open market. The rancher could then set parameters or guidelines as to when it would be sold or slaughtered, and this information would be available to the token holder. The benefit of this type of system is that a rancher could capitalize on their cattle through tokenization at any point but still manage

² “Blockchain.” *Merriam-Webster*, Merriam-Webster, www.merriam-webster.com/dictionary/blockchain.

³ “Introduction: The Parable of the Tree.” *The Blockchain and the New Architecture of Trust*, by Kevin Werbach, The MIT Press, 2018, pp. 1–14.

the cattle according to a predefined contract. From the buyer side, it would allow for an investment similar to that of traditional cattle futures to be made, but on an individual and cow-specific level, granting more nuance to the investment.

This first idea, while exciting, faces numerous pragmatic and regulatory hurdles. The discussion of this more complex integration is ongoing, but there are few, if any, examples of it being executed.

The second more pragmatic idea of application of blockchain for the beef industry is in supply chain management and traceability. Blockchain seems to be a natural fit for supply chain management and many large companies such as IBM and Walmart, are already developing food traceability systems integrated with Blockchain.

An example of process of using blockchain as a supply chain ledger for the beef industry works as follows. When the calf is born, basic information such as date and time of birth as well as more advanced data such as the genetic data of the parents will be recorded on a new blockchain. As the calf goes through the traditional branding and tagging process a RFID (or possibly Bluetooth) ear tag is attached and the connected with that cow's information on the blockchain. As any major or minor event in the life of the cow occurs, that block of information will be added to the chain, information such as vaccinations given, sales, medical procedures, transportation, giving birth, the use of certain hormones, or even changes in the feed given to the cow, amongst others. This data would be recorded to the specific cow by using a traditional RFID wand connected to a computer to scan the tag (a system already used by many in the beef industry in the US), or it could be done through any internet connected device. During slaughter additional information such as time and date, facility of processing, grade of meat, and even thickness of fat and marbling grading could be added. Finally, this blockchain stays with the meat throughout the whole meatpacking, transportation, and final sale processes, giving the end buyer and all of the intermediaries' access to the entire blockchain of information.

Not only does this system lead to the easier transfer and access of information between the various entities that work with or own the cow/beef, but it also enables incredibly fast traceability of the chain. Professor Werbach recounts the story of when a food safety executive at Walmart asked his team to identify which farm a package of mangoes came from. Using traditional supply-chain mechanisms it took the team a week. With blockchain that information was found in a few seconds.⁴

This supply chain traceability function of blockchain is the main, current use of blockchain in the food and beef industry and it is more realistically implementable in the near future. For these reasons, the supply chain traceability function of blockchain will be the main focus of blockchain integration in the beef industry as analyzed in this paper.

Limitations and Restrictions

⁴ "Chapter 4 - Why Blockchain?" *The Blockchain and the New Architecture of Trust*, by Kevin Werbach, The MIT Press, 2018, pp. 71–92.

Naturally, there are limitations and restrictions to blockchain integration to the beef industry that must be acknowledged. Limitations listed here are those that are general to blockchain integration holistically, but limitations or restrictions that are specific to certain proposals will be discussed in tandem with the proposals later in the paper.

Mobile Devices and Internet

The first and most obvious limitation to blockchain is that there needs to be access to a device that can access the internet to add to or view data on a blockchain. While this may be a factor of consideration in especially rural areas with limited cellular service, it is important to note that Kenya has a 91% mobile phone ownership penetration rate, and as of 2017 87% of the population is covered by 3G⁵. In the US the mobile phone ownership is at 96% penetration and 81% of the population owns a smartphone.⁶ While the level of smartphone ownership in Kenya is considerably lower, at 20.9% of the population⁷, it should be noted that this number is rising quickly. Additionally, the example of M-Pesa, a direct money transfer app that can operate without a smartphone show how this may not be a serious limitation. As of 2018, 96% of Kenyan households outside of Nairobi had a M-Pesa accounts, exceeding many developed nations in their usage of direct money transfer apps.

Proprietary Information

Another limiting factor of Blockchain is the desire for certain entities to keep their information on the cattle/beef private. Within a feedlot, producers may want to keep their proprietary feed mix secret and entities who have negotiated certain pricing may wish to keep that information private. A traditional blockchain has public data available to everyone, and this would create a disincentive to share information.

BeefChain CEO, Rob Jennings gives a possible solution to this issue in the form of a semi-permissioned blockchain. This system would only give access to people permissioned to be in the system, and the rights to this data would be sold with the cow. Some information like date of birth, vaccines, location, and breed may be public, but carcass weight, USDA grading or any other proprietary information could be permissioned, and only accessed by the owner of the cow/beef and its data.⁹

Ear Tags

Another seemingly small, but actually quite onerous limitation to blockchain integration is needed use of specialty ear tags. Most cattle in the US are ear tagged but in Kenya this phenomenon was quite rare, with the Maasai either cutting notches in the ears to denote

⁵ Namunwa, Kevin. "Kenya Leads Africa in Smartphone Usage." *Business Today Kenya*, 11 Mar. 2019, businesstoday.co.ke/kenya-leads-africa-smartphone-usage/.

⁶ "Demographics of Mobile Device Ownership and Adoption in the United States." Pew Research Center: Internet, Science & Tech, 12 June 2019, www.pewinternet.org/fact-sheet/mobile/.

⁷ "Top Countries/Markets by Smartphone Penetration & Users." *Newzoo*, newzoo.com/insights/rankings/top-50-countries-by-smartphone-penetration-and-users/.

⁸ "What Kenya's Mobile Money Success Could Mean for the Arab World." World Bank, 3 Oct. 2018, www.worldbank.org/en/news/feature/2018/10/03/what-kenya-s-mobile-money-success-could-mean-for-the-arab-world.

⁹ Jennings, Rob. Phone Interview. "Permissioned Blockchains." 8 August 2019.

ownership or cutting other markings in the hides.¹⁰ BeefChain was implementing blockchain through RFID ear tags, so that they may be paired with RFID scanners already used in conjunction with electronic ID (EID) systems by many operations and slaughter houses.¹¹ Bluetooth ear tags are also available but they are more fragile with encased electronics and they require batteries which needs extra labor to be replaced. These tags can be relatively expensive, costing between \$1-\$3 for a RFID enabled ear tag,¹² a considerable sum at low margin operations.

Data entry

A final possible limitation of blockchain integration in the beef industry lies with data entry. Immutable records are only as strong as the data that is entered into them, and there still runs a risk that either data is omitted, or inaccurate data is imputed, with or without intent. However, even in the event of incorrect data being added to the chain, blockchain does provide an advantage over traditional supply chain methods by providing a clearer, quicker means of tracking and identifying parties accountable for incorrect data.

Additionally, for truly comprehensive data on beef to be acquired there must be significant buy-in from all of the various parties involved, requiring a sort of “critical mass” to be developed. Slaughterhouses won’t take the time and energy to add their own blockchain enabled systems unless enough producers have the systems, and there must also be a critical mass element of consumers who either demand or increase their willingness to pay for beef with blockchain enabled supply chain records. Building these incentives for all of the entities involved requires educating large groups of people on the possible benefits of such a system, requiring lots of time and resources. A part of which, this paper hopes to accomplish.

Beef Industry Overviews

After discussing the background, specific applications, and possible limitations of blockchain integration in the beef industry as a whole, this section will elaborate on the beef industries, and blockchain integration opportunities of two sample countries – Kenya and the US.

While the beef industry of Kenya is less developed and less studied, more time will be taken to give an overview of its current beef industry and practices. In the case of the US, there is already much literature on the beef industry, so a shorter overview will be given. In addition, for Kenya more discussion will be given over proposals for blockchain integration, while the US section will focus more on current blockchain initiatives underway.

¹⁰ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019

¹¹ Jennings, Rob. Phone Interview. “Ear Tags.” 8 August 2019.

¹² “840 USDA FDX EID Ear Tags - 20 Ct Yellow.” Y, 2019, www.valleyvet.com/ct_detail.html?pgguid=EE6F9CF9-DD83-4A03-AC00-F7252296E8BA.

The Kenyan Beef Industry

Overview

Kenya was selected as the country to serve as a representative for a beef industry in a developing country. Kenya fits this description well, being labeled by the United Nations as a Developing Economy and as a Low-Income country measured by GNI¹³. Additionally, Kenya was selected for the vast importance that agriculture plays in the nation's economy. Of Kenya's approximately 50 million inhabitants¹⁴, roughly 40% of the entire population works in the agricultural industry.¹⁵ Agriculture makes up 65% of export earnings of Kenya¹⁶ and specifically the livestock sector of Kenya contributes to 12% of total Gross Domestic Product¹⁷.

Another reason for the selection of Kenya as a subject of study is the increasing standards of living and consequently a growth in consumption of beef. The GDP per capita of Kenya is expected to more than double from USD \$1300 as of 2013 to over USD \$3000 by 2050 and this coincides with a desire for Kenyans to have higher quality food like beef. ¹⁸ Beef consumption in Kenya has already increased from 15.81kg per household in 2003 to 19.1kg per capita in 2014¹⁹ and this number is estimated to increase over time. Demand may also be driven in the future by continued expansion into export markets, recently into more middle eastern nations.²⁰ Kenya also poses a number of interesting geographic and cultural factors that influence the beef industry. The varied landscape, topography, and weather patterns throughout Kenya influence where the various subsectors of the beef industry are located and how the industry is structured due to environmental factors. Within the context of this research, site visits were made to various arid and semi-arid regions located in the North and South sections of the Great Rift Valley²¹ as well as to the highlands region around Mt. Kenya including the Laikipia Plateau²². These areas experience vastly different weather and environmental conditions, requiring differing methods of cattle production.

Culturally, the Kenya has various cultural and tribal identities that play a role in the beef industry. While these specific groups are unique to Kenya, the overarching concept of including a cultural and tribal element of cattle/beef production may also be representative of various other beef industries in developing countries. Much of the pastoralism and nomadic pastoralism that

¹³ "Country Classification." *United Nations*, 2014, www.un.org/en/development/desa/.../2014wesp_country_classification.pdf.

¹⁴ "Kenya." *FAOSTAT*, 2018, www.fao.org/faostat/en/#country/114.

¹⁵ "Kenya at a Glance." *FAOSTAT*, FAO of the UN, 2019, www.fao.org/faostat/en/.

¹⁶ "Kenya at a Glance." *FAOSTAT*, FAO of the UN, 2019, www.fao.org/faostat/en/.

¹⁷ Shibia, Mumina, Shaikh Rahman, and Benaissa Chidmi. *Consumer Demand for Meat in Kenya: An Examination of the Linear Approximate almost Ideal Demand System*, 2017.

¹⁸ "Africa Sustainable Livestock - Integrated Snapshot - Kenya. Cattle and Poultry Sector." *FAO.org*, FAO of the UN, USAID, 2018, www.fao.org/documents/card/en/c/CA1830EN.

¹⁹ Shibia, Mumina, Shaikh Rahman, and Benaissa Chidmi. *Consumer Demand for Meat in Kenya: An Examination of the Linear Approximate almost Ideal Demand System*, 2017.

²⁰ "Saudi Lifts Ban on Kenyan Beef Products." *allAfrica.com* 25 Sept. 2014. *Business Insights: Global*. Web. 6 Aug. 2019.

²¹ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019.

²² Laikipia Plateau Region, Kenya. Personal Observations (Typed notes and pictures) 25 July 2019.

takes place in the arid and semi-arid Great Rift Valley region is conducted by members of the Maasai tribe²³. The Maasai are one of Kenya's 40+ recognized tribes and are recognized by many by their pastoral nomadism and their tribal ownership of land. Additionally, of the few, large ranches in located on the Laikipia Plateau in Kenya many are owned by the Mzungu, a term that refers to Kenyans of European origin/heritage (although it is also commonly used to refer to any foreigner)²⁴. Undoubtedly the tribal and cultural identities introduce a unique element to the Kenyan beef industry, but unfortunately one that is too complex to be appropriately addressed in this paper.

Pragmatically, the Kenyan beef industry also was selected as the representative for a number of reasons. Kenya has the size and scale of beef industry needed for adequate research to be conducted. Furthermore, Kenya proved to have the requisite level of safety, infrastructure, and ease-of-travel to make it a viable destination for performing research.

Supply Chain Overview

The Kenyan beef industry has an incredibly complex supply chain. Limited by the primary interviews and research I was able to conduct, this paper hopes to offer snapshots of what a beef supply chain in Kenya looks like according to the various areas studied.

Breeding

The supply chain of beef naturally begins with the breeding process of cattle. For the pastoral Maasai herders, their cows are seen as one of the main measurements of their wealth. As such, many herders talked about breeding cows and raising calves up until their carrying capacity was reached, limited by access to water, grazing land, or the labor needed to care for such a herd.²⁵ Breeding was largely informal and many of the cows appeared to be of mixed breed, but it was observed that "pure breed" bulls commanded a higher price at market, with favor to that of the Boran breed. For the large, commercial ranches run by the Mzungu, care was taken to maintain genetic purity of the herd as well as to maintain a sustainable herd size according to market conditions and ranch size and conditions. For example, the 44,000-acre Suyian Ranch maintained approximately 3000 pure Boran cattle while the nearby 30,000-acre Ol Maisor Ranch held around 2600 mixed Boran and Angus cattle, and they even sorted their smaller herds by color of the hide.²⁶

Raising of Cattle

For the raising of the cattle the conditions similarly vary according to the geography of production. The Maasai follow an extensive pastoralist method, moving cattle on private, but often tribally owned lands. The arid or semi-arid environment significantly lowers the livestock

²³ Motamu, Musei (Moses). Personal Interview. "Maasai Pastoral Nomadism Questions." 20 July 2019.

²⁴ Kwolek, Nick. Phone Interview. "Introduction to Agriculture in Kenya." 9 June 2019.

²⁵ Various Maasai Herdsmen. Personal Interviews. "Maasai Herdsmen Questions – Shompole Market." 23 July 2019.

²⁶ Laikipia Plateau Region - Suyian and Ol Maisor Ranches, Kenya. Personal Observations (Typed notes and pictures) 25 July 2019.

density in the region²⁷. A main limitation in the region is water, with the Kenyan military operating trucks that deliver water to some of the villages in the Rift Valley area on a daily basis. Typically, one Maasai man, sometimes accompanied by his son(s), attend to a herd of between 5-40 cattle and are sometimes mixed with goats and sheep. The men travel light, often carrying only a large stick to hit the cattle, a Maasai sword, and either a spear or bow and arrow to defend against predators.²⁸ At night the cattle are usually corralled into a Boma (traditional corral made of cut thorny bushes) and watched over to prevent predator attacks.

The Mzungu owned ranches are usually fenced and even sub-divided into sections to rotate the pastures used. The cattle are often left to roam freely during the day and are sometimes left unattended. The cattle are usually broken up into smaller herds of between 100-150 head. At night they too corral the cattle into Bomas for protection.²⁹

Sale of Live Cattle

Maasai herders are not typically selling when the cattle are at a particular maturity, rather they are selling either to receive cash flow or after the cow has become too old to be easily moved. In extreme cases of drought when lack of feed or water is imminent cattle may be sold for a fraction of their value, as sale may be the only means of salvaging any value of the cow. Sales occur at small, regional markets like that which was observed at Shompole, located near the Tanzanian border, approximately 80 miles from Nairobi. These markets have a large boma which cattle are brought to early in the morning or the night before sale. To store the cattle overnight, smaller private bomas have been erected and a man or woman from the village will charge 100 Kenyan Shillings (approximately \$1) to watch up to 10 or more of your cattle overnight, and they can usually fit perhaps 50 or so total cattle in these bomas. While the market is “open” every day of the week, the major sale, when outside trucks and buyers come into town, only occurs once a week. The actual selling of cattle is a decentralized process. Buyers may come around to the various owners of the cattle and simply make them an offer for their cattle. This price is not based on weight (there were no scales to my knowledge), but instead based on observations of the health and size of the animal in addition to any information the Maasai herder may be able to share, like age or breed.

At the Laikipia ranches, the cattle were sold in various methods, with Suyian Ranch noting that they moved their cattle to slaughterhouses in Nanyuki or Nairobi and then sold their beef directly to market, while Ol Maisor noted that they sometimes sold to middlemen, who would then organize their own transportation and slaughter.³⁰ Notably, both operations explicitly noted that they sold their cattle according to weight, and that they were given a premium due to the pure bred nature of their cattle and their better quality of beef. The going rate per weight ranged from 130-165 Kenya Shillings (KS) per Kilogram (approx. \$1.26-\$1.60/kg), with variability based on if it was a heifer or steer and the breed of cow.

²⁷ “Africa Sustainable Livestock - Integrated Snapshot - Kenya. Cattle and Poultry Sector.” *FAO.org*, FAO of the UN, USAID, 2018, www.fao.org/documents/card/en/c/CA1830EN.

²⁸ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019.

²⁹ Laikipia Plateau Region - Suyian and Ol Maisor Ranches, Kenya. Personal Observations and Interviews with Ranch Hands (Typed notes and pictures) 25 July 2019

³⁰ Laikipia Plateau Region - Suyian and Ol Maisor Ranches, Kenya. Personal Observations and Interviews with Ranch Hands (Typed notes and pictures) 25 July 2019

Transportation

Some herders in Shompole didn't actually sell their cattle but instead they simply pay truck drivers to transport their cattle to the markets outside of Nairobi, with the owners then simply riding along in the trucks to these markets. The cost to transport a cow via truck to the main slaughter market for cattle from this area, the Kesserian Market, is roughly 1000 Kenya Shillings (approximately \$10)³¹. The drive takes around 4-5 hours and between 20-40 cattle can be fit inside a truck, which may also be loaded with goats traveling on a mesh net hung over the cattle section.

Additionally, the herders may choose to pay to contract someone to walk their cow/cattle to the Kesserian market instead of taking a truck. The walk to Kesserian takes 6 days and costs 1500 Kenya Shillings (approximately \$14.50). Due to the higher prices this is presumably done when either rain prevents trucks from making it to the Shompole Market or when the cow/cattle is to be delivered to either a different slaughterhouse in Nairobi, or to an intermediate stop on the route to Nairobi.

For the Laikipia ranches, when the cattle were being directly moved from the ranch to the slaughterhouses, trucks were contracted for the transportation. From Ol Maisor to the premium slaughterhouse, Farmers Choice in Nairobi the drive takes around 8 hours. The contracted trucks would charge 35,000-40,000 Kenya Shillings (~\$340-\$390) and can fit around 20 cattle per truck. This price per cow, of 1750-2000 Kenya Shillings adds a significant cost per head compared to the transportation from Shompole. If the cattle are sold to a middle-man, then they must contract their own trucks and transportation of the cattle.³²

Slaughter

The slaughter process was observed at the Kesserian Market and partially at the Dagoretti Slaughterhouse. I was able to meet with a manager at the Kenya Meat Corporation but was unable to see the operation firsthand.

At the Kesserian Market, there is a market area where cattle are bought and sold that sits directly adjacent to the Kesserian Slaughterhouse. The Kesserian and Dagoretti Slaughterhouses both operate as a service, and not as a meatpacker in the US style. They never take ownership of the cattle and instead simply charge a fee per head for a cow to be slaughtered at their facility. At Kesserian the charge for slaughter was a flat fee of 500 Kenya Shillings (~\$4.85) while at Dagoretti Slaughterhouse the slaughter fee was 400 Kenya Shillings (~\$3.88). However, numerous other fees were often added, that contributed to a higher total price. For example, at Dagoretti Slaughterhouse there was a 70KS landing fee per head, a 150KS per head fee to stay in the boma until slaughter, and a 200KS meat inspection fee per head. Thus, assuming all of these fees are taken, the total real price of slaughter at Dagoretti more than doubles, to 820KS per

³¹ Various Maasai Herdsmen. Personal Interviews. "Maasai Herdsmen Questions – Shompole Market." 23 July 2019.

³² Laikipia Plateau Region - Suyian and Ol Maisor Ranches, Kenya. Personal Observations and Interviews with Ranch Hands (Typed notes and pictures) 25 July 2019

head. These fees vary per market, and the timing of slaughter to prevent the overnight boma fee is quite important.³³

Because the slaughterhouse is not taking ownership of the cow/beef there is no live or carcass weighing process done at these slaughterhouses. As the cattle are brought in, it is the job of owner to either watch his carcass and all of the other parts or contract this job to someone who is working in the slaughterhouse. While the slaughterhouse does not take ownership of the cow normally, there is an option to sell the non-beef parts of the cow to the slaughterhouse, including the offal, hide, horns, hooves, tail, head, and other such parts. Naturally, if an owner of the cow wants to retain all of the products, tracking the various parts becomes a complicated effort.³⁴

While the operations at Kenya Meat Corporation (KMC) couldn't be observed, I was able to talk to Peter Arakawa, a manager there.³⁵ KMC is government owned and provides beef to various governmental entities such as the Kenyan military and Universities, as well as selling to the general market and exporting some of their beef as well. They provide both contract slaughter services, which accounts for approximately 30% of their business and also a purchase-then-slaughter model, which accounts for 70% of their business. For the contract slaughter, they charge a set fee of 1800KS per head, significantly higher than that of the aforementioned markets. In the purchase-then-slaughter model, herders bring their cattle to KMC's boma where then they are purchased based on a grading scale and inspected by a vet. They are then held and fattened until they are ready for slaughter. All of the cattle are slaughtered Halal, and as such are enabled to be exported to Muslim majority countries in the middle east.³⁶

Final Sale

From the Kesserian and Dagoretti Slaughterhouses the meat is transported in certified meat boxes on the back of a motorbike or pickup truck to local butchers' shops. The boxes are made of metal but are not insulated or refrigerated. These drivers are either contracted by the owners of the beef or they may have purchased the cow pre-slaughter at the market. From there the drivers make deliveries to several butcher shops and must provide a veterinarian inspection certificate to each butcher shop. At the butcher shop the carcass is weighed and a price per kilogram is negotiated.

To the end consumer prices vary significantly based on the location of the butcher shop. For the butcher shops located directly next to the Kesserian market, the going rate for a kilogram of beef was 350KS/kg. (~\$3.40/kg) However butcher shops a few blocks away were selling for price ranging from 400-550KS/kg (\$3.88-\$5.33/kg) and butcher shops that were located only 5 minutes' drive from the market were selling for 600KS/kg (\$5.82/kg)³⁷. Prices in downtown Nairobi were reported to be even higher. These prices ranged despite the origins and quality of the beef being identical. In these butcher shops the price for beef and goat meat was often the

³³ Dagoretti Slaughterhouse - Personal Observations and Interviews with Slaughterhouse employees (Typed notes and pictures) 24 July 2019

³⁴ Kesserian Slaughterhouse - Personal Observations and Interviews with Slaughterhouse employees and veterinarians (Typed notes and pictures) 22 July 2019

³⁵ Arakawa, Peter. Personal Interview. "Kenya Meat Corporation Information." 22 July 2019.

³⁶ Arakawa, Peter. Personal Interview. "Kenya Meat Corporation Information." 22 July 2019.

³⁷ Kesserian Slaughterhouse - Personal Observations and Interviews with Slaughterhouse employees and veterinarians (Typed notes and pictures) 22 July 2019

same price, and the price per kilogram applied to any section of the carcass desired. This meant that there was no premium for select cuts or sections of beef. These shops often have one or two full beef carcasses and several goat or lamb carcasses. The meat is not refrigerated or frozen but is kept dry and an effort is made to prevent flies. These types of shops serve a large majority of the local Nairobi population.

The cattle from the Laikipia ranches seemed to go to various locations, but generally were sold to slaughterhouses and end buyers who were targeting premium quality meat. This beef makes its way to the higher-end grocery stores, hotels, and restaurants within Kenya and this meat also appeared more likely to be exported.

Regulatory Environment

The regulatory environment relating to beef in Kenya is mostly focused around food safety. During the many site visits I was able to meet with various veterinarians who are traditionally employed by the local and county governments and working under as part of the Directorate of Veterinary Services in the Ministry of Agriculture, Livestock, Fisheries, and Irrigation³⁸ at various stages throughout the supply chain.

Starting with the rural, regional market of Shompole, a veterinarian was present at the market to perform visual checks on the cattle before they were transported to the Kesserian market. The vet said that he was checking “overall fitness” of the animals and checking to make sure that no diseases were visually present³⁹. This was done in an effort to prevent the spread of disease to other regions. A 20KS (~20 cents) fee is charged per cow inspected as the cattle are brought on to a truck for transport. The vet then issues the driver of the truck a hand-written certificate certifying that the cattle are safe to be transported.⁴⁰

At all of the various slaughterhouses, veterinarians were present and oversaw the slaughter process. The veterinarian at the Dagoretti Slaughterhouse described their process to me as follows. First a pre-mortem inspection is carried out and any suspect animals are put into a separate pen, to be slaughtered in the last batch of the day. After the cow is killed and slaughtered the veterinarian inspects the carcass and cuts open the liver and inspects other organs. If the meat is approved for human consumption, the carcass is then stamped by the veterinarian. If either disease or parasites are found in the carcass, the veterinarian has the right to condemn either all of part of the carcass as needed. The vet charges 200KS per head for the inspection and gives the owner a written slip showing that the carcass has been inspected and detailing the date and location of slaughter.⁴¹

After the meat is sold, the jurisdiction for the safety of the meat is transferred to the Ministry of Public Health.⁴² It is their responsibility to go to the various butcher shops and inspect the

³⁸ “Organization Structure.” *Ministry of Agriculture*, www.kilimo.go.ke/?page_id=291.

³⁹ Veterinarians at Shompole. Personal Interviews. “Veterinarian Questions – Shompole Market.” 23 July 2019.

⁴⁰ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019.

⁴¹ Dagoretti Slaughterhouse - Personal Observations and Interviews with Slaughterhouse employees (Typed notes and pictures) 24 July 2019

⁴² “Organizational Structure.” *MINISTRY OF HEALTH*, 2017, www.health.go.ke/about-us/organizational-structure/.

conditions of the meat. If prompted, the butcher store owner must be able to produce the paper from the slaughterhouse vet, showing the information of the time, date, and location of the slaughter as well as which vet had certified the carcass. ⁴³

Problems

Despite the relatively large size of the beef industry in Kenya its related supply chain systems are not on par with the sophistication of more developed beef industries like that of the US. Consequently, many of the problems solved by the supply chain and regulatory systems in the US beef industry are still unaddressed. In this paper I have addressed three key problems within the Kenyan beef supply chain that could be addressed with blockchain solutions: ownership records, food safety, and price transparency.

Ownership Records

Of note to me during my visits to both the Shompole market and the Kesserian Market and Slaughterhouse was the ease at which cattle traded hands. The buyer would make an offer and if the owner agreed they shook hands and either exchanged cash or otherwise promised to pay (possibly by M-Pesa) and then the buyer took the cattle.⁴⁴ While this was a quick and trust-based system, it also points to the lack ownership records for the owner of the cattle. No documents were signed and there is no paper-trail of the transaction.

The lack of ownership documentation creates problems at several points in the supply chain. At the transaction level, lack of documentation creates a risk of fraud as well as an inability to tax such a transaction. With fraud, the lack of any formal contract or documentation creates an inability for either the owner or seller to have recourse should they be defrauded in the transaction. From my various conversations and observations these markets are relationship based, creating a level of trust amongst participants that mitigates fraud and other transactional disputes. In the case of the Shompole market, when a disagreement between buyer and seller arises the Chief of the local tribe is the one who arbitrates the solution.^{45,46} While this may work at a local scale, these systems may prove ineffective as the beef industry grows from the regional to the national and international scale.

Another transaction point issue with the lack of ownership documentation is taxation. The lack of documentation and direct sale of cattle prevents the government from ever being able to tax the sale of cattle. Small market villages like Shompole may conduct a great deal of transaction volume in their town but are unable to derive tax revenue from their market, perhaps limiting their financial resources to provide public services such as education and community infrastructure.

⁴³ Veterinarian at Dagoretti Slaughterhouse. Personal Interview. “Veterinarian Questions – Dagoretti Slaughterhouse.” 24 July 2019.

⁴⁴ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019.

⁴⁵ Kesserian Slaughterhouse - Personal Observations and Interviews with Slaughterhouse employees and veterinarians (Typed notes and pictures) 22 July 2019

⁴⁶ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019.

The greatest opportunity positive social impact of using blockchain to expand ownership records however may be at the owner level. Many of the Maasai herdsmen that I spoke with owned between 20 and 200+ cattle, making their net worth very high by Kenyan standards. Yet, because nearly all of their net worth was tied into the living cattle they owned, if they wanted to access any of this wealth they had to sell their cattle to create that cash flow. In several interviews, herdsmen and buyers mentioned that the sale price of cattle is lowest during the time of year when school fees are due, as herdsmen must sell their cattle to have the funds to pay the fees. Additionally, I heard tales of owners being forced to sell their cattle at inopportune times in order to get cash to pay for a medical expense or for a needed home improvement.^{47 48}

The lack of paper or electronic records severely limits the ability for owners to use their cattle as collateral on a loan to pay for these expenses. This creates a whole group of people who have a relatively high net worth in assets but a severely limited access to capital. As a consequence, market prices fluctuate due to seemingly unrelated factors and herdsmen get less money per head when they need it the most.

A mobile supported blockchain record of ownership could fix this gap by allowing herdsmen to grant banks access to their ownership records to confirm how many cattle the herdsman owns at any given time and more precise data on the age and possibly even breed and sex breakdown of cattle owned, in order for the bank to give an accurate valuation of the herd to use as collateral in a loan. Additionally, such a system could also be implemented to improve the transaction side as well. As a deal is struck the “title of ownership” could be electronically transferred from the seller to the buyer and other integrations into such a platform could even transfer money or cryptocurrency electronically as part of the transaction.

An example of another issue that could be aided with a blockchain system of ownership recordkeeping is that loss to wild animals. To combat retaliatory killing of wild predators that kill livestock, the Kenya Wildlife Service and other non-profit funds will compensate herdsmen after performing an investigation into the death of the animal.⁴⁹ This system of compensation however is often slow and laborious for the affected herdsmen and there is also a perverse incentive for some herdsmen to leave weak and sick animals vulnerable to attack in order to collect compensation, straining such initiatives. A blockchain record of ownership may expedite the investigation process in the event of livestock loss to predators and also flag bad actors who are abusing the system for financial gain. This could in turn provide positive environmental outcomes by reducing retaliatory killings of predators and ensuring that the limited compensation funding is appropriately given to those affected.

Food Safety

Another problem that is of paramount concern in Kenya is food safety. Almost all of the current governmental regulation in relation to the beef industry is currently focused on ensuring food

⁴⁷ Motamu, Musei (Moses). Personal Interview. “Maasai Pastoral Nomadism Questions.” 20 July 2019.

⁴⁸ Various Maasai Herdsmen. Personal Interviews. “Maasai Herdsmen Questions – Shompole Market.” 23 July 2019.

⁴⁹ Muriuki, Margaret W., Hellen Ipara, and John W. Kiringe. “The Cost of Livestock Lost to Lions and Other Wildlife Species in the Amboseli Ecosystem, Kenya.” *European Journal of Wildlife Research*, vol. 63, no. 4, 2017, pp. 1-11.

safety to the consumer and preventing the spread of zoonotic and other diseases that may cause harm to humans or to other animals.⁵⁰

While the previously mentioned regulatory environment attempts to prevent the spread of animal disease and ensure the safety of beef consumed, the government resources can be spread thin, and often they are only overseeing the formal slaughterhouse and market systems within the beef industry in Kenya. Many cattle, especially sick or injured cattle, are not brought through these formal channels either due to the lack of access to a slaughterhouse in rural areas or out of concern that the beef of sick cattle may be condemned without compensation. This leads to a whole segment of cattle that are “home slaughtered”, and some of this meat may end up in butcher shops passed off as certified and inspected meat.

Additionally, even with the current system of veterinarians at various points throughout the supply chain, there is a chance that a diseased cow still makes it to either a slaughterhouse or even to market as beef. The failure of any one part of the slaughter process could lead to contamination that could endanger beef in numerous butcher shops and restaurants around various parts of Kenya.

A blockchain ledger system of records could help solve these issues. For the prevention of the sale of counterfeit certified beef, a blockchain ledger would hold information regarding when the animal was slaughtered and by whom. This would enable butcher shops and other retailers to have greater confidence that the beef that they are buying has been properly processed and would even allow butchers to see how recently the cow was slaughtered to ensure that they are being sold fresh beef. This latter point is especially pertinent, given a recent expose of the practice of adding Sodium Metabisulfite (commonly known as sulfites) to meat to make it appear fresher.⁵¹

For the prevention of the spread of disease, the a blockchain system would provide the groundwork for a significantly more accurate method of tracking the origins of the disease or contamination. If a contamination from the slaughterhouse is found, tracing the blockchain backwards would almost instantaneously yield information regarding not only which slaughterhouse it came from but also the exact date, time, and possibly even certifying veterinarian. From here a quick intervention can be made to the slaughterhouse and parties responsible, and any other owners of beef that was also slaughtered on this date, time, and location may be notified of possible contamination. The health safety and economic benefits of such a system would be enormous, allowing contaminations and diseases to be brought under control quickly and preventing a report of contamination in an otherwise isolated case from causing damage to the whole industry.

⁵⁰ Veterinarian at Dagoretti Slaughterhouse. Personal Interview. “Veterinarian Questions – Dagoretti Slaughterhouse.” 24 July 2019.

⁵¹ Ngila, Faustine. “NGILA: Use Blockchain to Save Kenya's Meat Industry From.” *Daily Nation*, Daily Nation, 22 July 2019, www.nation.co.ke/oped/opinion/Use-blockchain-save-Kenya-meat-industry-/440808-5206040-vapjwk/index.html.

Price Transparency

The final problem that could be solved through a blockchain integrated system is price transparency. Throughout my interviews⁵² and observations it was noted that middlemen within the supply chain seem to be making the most money. For example, a cow that was purchased at Shompole for roughly 13,000KS could easily be sold at the Kesserian Market for 30,000+KS, despite it being only a 5-hour drive.^{53 54} Then as aforementioned, prices varied largely based on proximity to the market, with an over 70% jump in the price per kilogram of identical beef observed between butcher shops located within a 5 minute drive of each other.

The opacity of pricing of beef in Kenya seems mainly to be a byproduct of the lack of mobility of various actors in the supply chain. At the production side, the Maasai tribesmen often have no ability to leave their home and the rest of their herd to make the 6-day walk to the Kesserian market themselves. On the consumer side, many Kenyans are walking to their neighborhood butcher shop and don't have the ability to travel very far to price shop, creating extreme price variation within relatively short distances.

If transaction data were to be made available in a blockchain integrated system this pricing information would be exposed. This would remove the opacity of the market and perhaps encourage new entrants into the market to undercut established middlemen who thrive off of this opacity. The Maasai herdsman may gain bargaining leverage knowing how much their cattle are actually selling for in the markets and consumers may gain a better understanding of where to buy their beef to get the best price.

However, this proposed solution would be perhaps hardest to implement. While the primary producers and the end consumers may ultimately benefit, there is little benefit for middlemen to participate in such price transparency, giving that it might ultimately hurt their margins. Additionally, while greater price transparency is widely considered a good thing, simply increasing transparency doesn't solve any of the mobility issues, suggesting the access to pricing information may not actually alter the current prices and margins earned.

Current Interest in Blockchain for the Beef Industry

In the various interviews with individuals throughout Kenya there seemed to be a general understanding of, and interest in, blockchain.⁵⁵ However, in all of my conversations I couldn't seem to find any individual or organization that was directly trying to implement a system of blockchain integration to the beef industry, but the importance and excitement of the idea is not lost on those in Kenya.

⁵² Various Maasai Herdsmen. Personal Interviews. "Maasai Herdsmen Questions – Shompole Market." 23 July 2019.

⁵³ Shompole, Kenya and Great Rift Valley Area. Personal Observations (Typed notes and pictures) 23 July 2019.

⁵⁴ Kesserian Slaughterhouse - Personal Observations and Interviews with Slaughterhouse employees and veterinarians (Typed notes and pictures) 22 July 2019

⁵⁵ Arakawa, Peter. Personal Interview. "Kenya Meat Corporation Information." 22 July 2019.

During my research in Kenya an opinion piece in a prominent Kenyan Newspaper titled “Use blockchain to save Kenya’s meat industry from adulteration” was published.⁵⁶ The article discusses the problem of meat adulteration with the addition of Sulfites and how blockchain technology could help improve traceability and verification of the freshness of meat, among other points. Additionally, the article mentioned how such a system could also increase price transparency and reduce the cost of meat by removing unnecessary middlemen.

There is also interest in blockchain integration to the beef industry in other parts of Africa. In an interview with the CEO of BeefChain, Rob Jennings he mentioned that they are working with a local partner in Zimbabwe to help establish a blockchain system there.⁵⁷ Andrew Uden, President of AgVision International, an agribusiness consulting firm with a focus on Africa, also mentioned the importance of Blockchain as being integrated as a piece of a much larger system of traceability and food security that must be developed in African nations.⁵⁸

The inefficiency and lack of a developed traceability system within the Kenyan beef industry creates even greater opportunities for positive social and economic impact with the integration of a blockchain based system. Yet this same lack of a developed system also means that the economic and practical barriers to implementing such a system are much higher. The next section of the paper focuses on the highly developed beef industry of the United States, to give a comparative aspect of opportunities through blockchain integration to the beef industry.

The US Beef Industry

Overview

The beef industry is a key industry for the US, both domestically and internationally. According to the USDA, Agriculture, Food, and Related industries contributed \$1.053 trillion dollars to GDP, representing a 5.4% share of GDP.⁵⁹ Specific to the meat industry, the North American Meat Institute reported that in 2016 the meat industry employed over 1,800,000 Americans and created \$348,000,000,000 worth of output.⁶⁰ Domestically this not only creates positive economic impacts for those directly involved in the industry but it also creates a market of high quality and relatively low priced beef for consumers, with Americans spending less on food than any other developed nation in the world, specifically on meat and poultry.⁶¹ (See Graphic)

⁵⁶ Ngila, Faustine. “NGILA: Use Blockchain to Save Kenya's Meat Industry From.” *Daily Nation*, Daily Nation, 22 July 2019, www.nation.co.ke/oped/opinion/Use-blockchain-save-Kenya-meat-industry-/440808-5206040-vapjwk/index.html.

⁵⁷ Jennings, Rob. Phone Interview. “BeefChain initiatives in Zimbabwe.” 24 July 2019.

⁵⁸ Uden, Andrew. Phone Interview. “Ugandan and East African Beef Industries.” 15 April 2019.

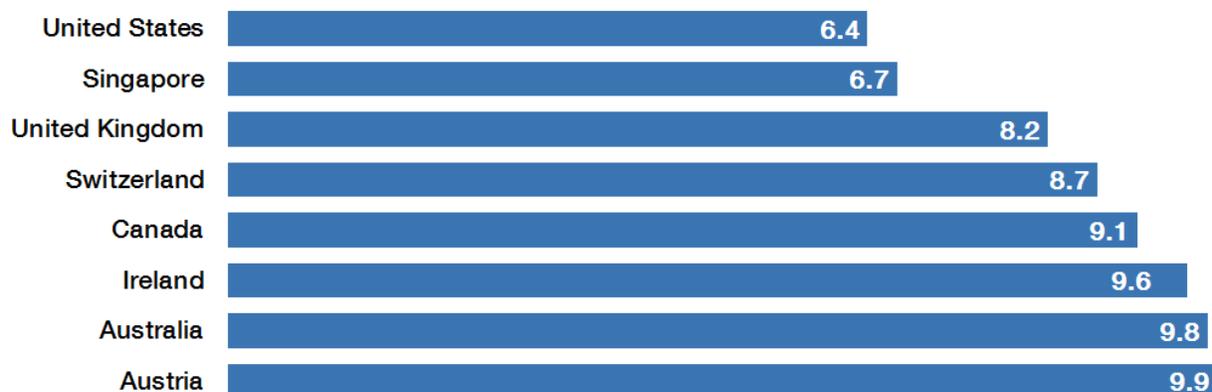
⁵⁹ “Ag and Food Sectors and the Economy.” *USDA ERS - Ag and Food Sectors and the Economy*, 16 Apr. 2019, www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/ag-and-food-sectors-and-the-economy/.

⁶⁰ “Economic Impact.” *Meat Fuels America*, 2016, www.meatfuelsamerica.com/content/2016-economic-impact-analysis.

⁶¹ “North American Meat Institute.” *The United States Meat Industry at a Glance*, www.meatinstitute.org/index.php?ht=d%2Fsp%2Fi%2F47465%2Fpid%2F47465.

These countries spend the least on food

Percent of consumer expenditure spent on food that was consumed at home, by selected countries, 2015



Source: ERS, USDA calculations based on data from Euromonitor International

Beef exports also contribute heavily to the US economy, with exports accounting for 12.9% of beef production and an export value of \$7.27 billion as of 2017.⁶² The top four export destinations of US beef are Japan, South Korea, Mexico, and Hong Kong as of 2017, and a recent push by the Trump administration has expanded beef exports to the EU and opened new beef markets in Tunisia, Morocco, and Australia.⁶³

At a more the local and state level the importance of the beef industry is even more pronounced, with many communities reliant on the cattle and beef as a main economic driver.

Supply Chain Overview

The supply chain of beef in the United States is very complex, yet it is quite well documented in industry and academic literature. For this paper, site visits were made primarily in the Platte County area of Nebraska. The supply chain overviewed in this paper is largely indicative of this area and will serve primarily to demonstrate the various entities and processes involved with an example beef supply chain of the US.

The beef supply chain naturally starts with breeding. Several of the cattle producers that I visited in Platte County, NE mentioned buying their calves direct from cow-calf operations in Montana.⁶⁴ These cow-calf operations are located throughout the mid-west and western US and focus on breeding calves. The operations sometimes not only operate as cow-calf but are also in

⁶² “North American Meat Institute.” *The United States Meat Industry at a Glance*, www.meatinstitute.org/index.php?ht=d%2Fsp%2Fi%2F47465%2Fpid%2F47465.

⁶³ Trump, Donald J. “Remarks by President Trump at Signing of a U.S.-EU Trade Agreement.” *The White House*, The United States Government, 2 Aug. 2019, www.whitehouse.gov/briefings-statements/remarks-president-trump-signing-u-s-eu-trade-agreement/.

⁶⁴ Loseke, Ryan and June. Personal Interview. “Cow-Calf purchases.” 13 August 2019.

the fat-cow and stocker cattle operations, meaning they are raising the calves beyond being weaned off of their mothers and possibly until they reach slaughter size. Calves are typically branded and tagged at approximately 2-3 months old.

In the case of the Platte County feedlots, some calves, at this stage called feeder cattle, are bought directly from the cow-calf operations, often through pre-existing relations with the operations. Other times these feeder cattle are brought to a cattle auction house or “Sale Barn”, and sometimes they are sold virtually as the auctions are livestreamed on the TV and the internet.⁶⁵ At auction, many of the feeder cattle are brought into the pen and the auctioneer will announce the breed, weight, age and possibly other information. The Sale Barn may create their own rules requiring vaccines for the cattle, but the Sale Barn visited in Columbus, NE only states that vaccines are strongly encouraged. It was also noted that the vaccines “pay for themselves” as cattle without vaccinations typically sell for a lower price than those vaccinated.⁶⁶

Once purchased, the feeder cattle are transported to various feedlots in the vicinity of Columbus, Nebraska. At the feedlot, the cattle are typically brought into the feedlot’s own data recording system, sometimes an electronic system or in a few cases a paper system. Some new owners may choose to remove the old ear tags and replace them with new tags with a different system or some simply add their own, second tag to the other ear.⁶⁷ Throughout the cow’s life at the feedlot, important information such as vaccination records, medical procedures, records of illness, and even more specific and possibly proprietary data such as feed mix or which specific pen the animal was held in is typically recorded on these systems. Sometimes this is implemented through the Electronic ID (EID) ear tag using a RFID scanner wand and a handheld electronic device.

Once the cattle reach a target weight for slaughter, (the weight commonly referenced was ~1400 pounds) the cattle are then sold to various meatpackers in the vicinity. However, except for the largest operations, most feedlots cannot sell directly to a large-scale meatpacker as the number of cattle that reach the ideal slaughter weight at the same time does not amount to enough to fill a whole truck or warrant a buyer from one of the meatpackers to come out to make the purchase. In that case, cattle owners have a few options. The first is to sell the “fat cows” at the Sale Barn. At these auctions there often will be buyers from the meatpackers who are present to buy smaller lots of cattle to create a steady stream of cattle for the meatpacking facility. Another option is to sell to or through a middleman. These middlemen charge a fee per head and work to organize many smaller farmer’s and feedlot’s cattle into large enough lots to then sell directly to the meatpackers.

Once sold to the slaughterhouse/meatpacker the cattle are then often sorted and logged into the slaughterhouse or meatpacker’s internal system. After the animal is rendered senseless, the carcass is tagged with a barcoded tag.⁶⁸ As the carcass moves through the initial stages of cleaning and processing, this tag stays with the majority of the carcass, until it reaches the

⁶⁵ Bock, Travis. Personal Interview. “Cattle auction and sale processes.” 12 August 2019.

⁶⁶ Bock, Travis. Personal Interview. “Cattle auction and sale processes.” 12 August 2019.

⁶⁷Platte County, NE Feedlots. Personal Observations (Typed notes and pictures) 13 August 2019.

⁶⁸Cargill Meatpacking Plant, Schuyler, NE. Personal Observations (Typed notes) 10 August 2019.

grading stage. As the hide is removed from the carcass a safe paint is applied to a section of the carcass if the cow qualifies as Black Angus, a denomination that will earn a higher retail price.

At the grading stage the carcass is sliced open to reveal the Ribeye cut. Then a high-tech camera system operated by a plant worker takes a photo of this cut and it automatically analyzes the fat thickness and marbling which then grades the meat according to USDA standards. However, this grade isn't official, as further down the line a USDA worker will manually grade the meat themselves, though the two are rarely in disagreement.⁶⁹ After the carcasses have been graded they are organized in hanging racks according to designation. At this point the carcasses observed lose their original tags used at entry of the meatpacker, but it was noted that because the operation is so well-organized specific carcasses can be traced backwards as the whole system is meticulously timed to the second. The cattle are slaughtered in batches according to their grading so that all of the carcasses of one grade are processed simultaneously as to not mix up the grades of meat.

After being cut and processed the meat is packaged according to grade and cut of meat. The meat is only ever temporarily held at the meatpacking facility, usually no longer than 72 hours. Barcodes and tracking labels attached to the boxes that are shipped out would be able to give information regarding the meatpacking facility, but there is often no information regarding the origin of the beef from before the slaughter.⁷⁰

Regulatory Environment

The regulatory environment in the United States is naturally far stronger than that of Kenya and other developing nations. Throughout the slaughter, transport, and branding process the government will have regulatory oversight and presence to ensure animal welfare and food safety.

In relation to blockchain, the branding regulatory process is quite interesting. In Nebraska for example, the Nebraska Brand Committee, created by the Nebraska State Legislature in 1941, is the official group to regulate the brands used on cattle in Nebraska and investigate missing and/or stolen cattle.⁷¹ This process of branding is seen by many as quite antiquated, but it serves as the last line of defense against the theft of cattle since brands, unlike ear tags, are not removable. The process of brand inspection, and of registering cattle who are grazing in Nebraska from other states could be automated via a Blockchain system. This would also ensure that brand information is transferred with the cattle upon sale and organizations like the Nebraska Brand Committee would be able to track the ownership of cattle with specific brands.

Another key point of the regulatory process is the USDA inspection of meat at slaughterhouses. The USDA's Food Safety and Inspection Service (FSIS) enforces the US's Federal Meat Inspection Act, requiring that an inspector is present at all slaughter facilities and granting these inspections much jurisdiction beyond just grading the meat. They are tasked with overseeing the whole process, from the offloading of cattle from the trucks to the slaughter process. They have

⁶⁹ Cargill Meatpacking Plant, Schuyler, NE. Personal Observations (Typed notes) 10 August 2019.

⁷⁰Houfek, Christopher. Personal Interview. "Cargill Meatpacking Facility and Traceability." 10 August 2019.

⁷¹ "Nebraska Brand Committee" *Welcome – Nebraska Brand Committee*, <https://nbc.nebraska.gov>.

jurisdiction to condemn any meat that they find unsafe and the ability to shut down slaughterhouses for any safety or animal welfare violations.⁷² Blockchain is also relevant to this aspect of regulator oversight, as it would be important to both slaughterhouses and producers to track where any condemned carcasses are coming from to ensure that certain practices can be implemented to prevent it going forward, saving both parties time and money.

Problems

While the US beef industry has a much more well documented and regulated supply chain than Kenya or other developing beef industries, inefficiencies and abuses of the complex supply chain still exist. This section aims to elucidate the problems within the US Beef Supply chain that could be addressed through blockchain enabled systems or processes. Current blockchain initiatives in the US will be reserved for the subsequent section.

Food Safety

The US has a heavy regulatory stance within the beef industry to ensure food safety, protecting both domestic and foreign consumers and markets. However, despite the much stronger regulations and the impressive standards that meatpackers are held to in the US, there is still always a concern regarding food contamination or mislabeling.

In regard to food safety, the benefits of a blockchain enabled traceability system are similar to that of Kenya, or the system used by the food safety executive at Walmart. Should contamination in beef, or even disease in a live cow be found, a blockchain system would enable an instant and precise response to remove the product or trace the origins of the beef or cattle to the point of issue. The importance of the precision of this response is also important to consider from a consumer perspective. When a meat (or any other produce) contamination scare occurs, consumers and retailers tend to avoid the product altogether out of an abundance of caution. This creates huge negative economic ramifications for entire industries because of the poor practices or misfortune of one or a small number of bad actors. If a contamination was traced through a blockchain system retailers could be quick and precise, only removing the product that is directly at risk of contamination, and consumers would probably never notice its removal, creating trust in the system and ensuring industry stability.

Another integral aspect to the trust in food safety practices in the US is related to food labeling. Consumers naturally want to know the information associated with the beef that they are eating, but only some of this information is certified by a governmental agency like the USDA. In an effort to get earn a premium when selling their beef, many producers turn to private companies or organizations that will charge a fee to grant a certification of a specific label if certain requirements are met⁷³. Additionally, meatpackers and slaughterhouses may choose to slaughter

⁷² “FSIS: Inspection for Food Safety: The Basics.” *FSIS*, 2013, <https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/production-and-inspection/inspection-for-food-safety-the-basics/inspection-for-food-safety-basics>

⁷³ Mueller, Brandon. “Process Verified Program.” Samson, LLC - Process Verified Program, 2012, samson-inc.com/pvp.php.

according to religious slaughter doctrines such as Halal or Kosher in order to target a more niche market and charge a higher rate. However, all of these certifications are incredibly hard to track and follow from a consumer or retailer perspective.

A blockchain enabled system would allow for greater consumer confidence in certifications by providing the direct details related to the certification. For example, if a retailer or restaurant wants to sell only Hormone-Free beef, a blockchain traceability system would not only show the data of a certifying agency but also would even show the medical records of the cattle, giving direct access to the purchaser of the cow's medical history. This type of system would also allow consumers to have more direct information regarding the certifications. A great example of this is the designation "Grass-fed" beef. This designation is very vague as to how much of the cow's life was spent on a purely grass-fed diet, yet consumers may have a higher willingness to pay for such a designation. A blockchain system could even denote the specific requirements used for a certification to be granted, again increasing transparency to the end purchaser.

Contract Execution

Another issue within the US beef supply chain that was brought to my attention was that of that of abuses and inefficiencies in the process of the sale of cattle and completing the transaction. At the Columbus, NE Sale Barn the issue of people buying cattle on "float" was relayed.

Essentially, the current system allows for people to purchase cattle at an auction on Friday but wait to write the check until the following week. In the meantime, they may be able to sell the cattle to a different party, essentially allowing them to buy, own, and then resell cattle on the market without having actually invested paid for the cattle that they have already re-sold. This creates actors in the system who have no "skin-in-the-game" thus also adding liability of defaulting should they not make the sale and be unable to pay for the cattle they bought.

Additionally, certain rules dictate that the Sale Barn is required to make payment to the sellers within 7 days, adding significant liability to the Sale Barn to ensure that they get the buyer to write the check. This liability also intrinsically adds to the costs of the Sale Barn, a cost that is ultimately passed along to the buyers and sellers at the auction.⁷⁴

A blockchain traceability system could include an element that records both when cattle are "bought" and when the payment for such a purchase is recorded by the auction house and the seller. This would mitigate the issue of people who are buying on float, as any buyers of their cattle could see that payment has not been processed and auction houses could possibly restrict these individuals from taking part in their auctions.

Information Sharing

A final inefficiency within the US Beef Supply chain pertains to the sharing of information amongst actors across the supply chain. With the current system of information and record transfers at point of sale, only the requisite information needed for the sale is often exchanged. While this ensures that necessary information such as immunization records are distributed properly, much valuable information is lost as the cattle and then beef changes hands from one owner to another.

⁷⁴ Bock, Travis. Personal Interview. "Cattle auction and sale processes." 12 August 2019.

Take the example of the USDA grading of beef. When a carcass is rated as “Prime” by the USDA it garners the producer a bonus, as this high marbling and fat content beef can be sold at a premium, usually to restaurants or through specialty stores. Some meatpackers such as Cargill give a report back to feedlots and other producers giving them a breakdown of how the carcasses of their cattle were graded. Because of this bonus, naturally feedlots want to buy and raise cattle that are more likely to earn this “Prime” bonus. Some feedlots are able to use this data given to them by the meatpacker to then find out which cow-calf operation produced the highest percentage of prime graded cattle. Sometimes, feedlots may willingly share this grading information of the carcasses with the Cow-calf operation, but this seemed to a completely optional process⁷⁵. Naturally, a cow-calf operation would love to use this data to further enhance their breeding operations and increase the percentage of calves that end up being rated as “Prime”, but feedlots have a short-term incentive to withhold this information to create better informational leverage in their buying process.

A permissioned blockchain system could be negotiated into the price of the cow, essentially selling the data and/or access to the data with the cow. A permissioned blockchain would ensure that only parties who have “paid” to maintain access to the blockchain could access certain proprietary data points, such as the feed mix and genetic data. This would enable breeders in the cow-calf operation to have access to this valuable data to improve their operation and would enable feedlots to recognize producers that continually provide outperforming calves. While this information could be commoditized, both parties may also opt to share it openly, as breeders can improve their process and feedlots can buy better performing calves, improving the whole industry.

Current Blockchain Initiatives

With an incredibly strong beef industry and a robust tech sector, the US is a leader in connecting the worlds of blockchain and the beef industry. Many large companies and organizations are integrating blockchain to their supply chain traceability systems more broadly. IBM is pioneering the space with their initiative IBM Food Trust, a permissioned blockchain system that offers a whole suite of supply chain traceability and services to members up and down the supply chain.⁷⁶ Walmart has partnered with IBM in this initiative and through the size of both companies they are able to gain significant traction in the agriculture and food industry.

In other meat industries more specifically, there is also significant interest in blockchain solutions to supply chain problems. A new company Fishcoin promises to use blockchain based crypto-currencies to help improve traceability and regulatory compliance in the fish and aquaculture industry⁷⁷. Even Cargill has piloted a program to allow consumers to use a blockchain enabled system to trace their turkey back to the farm in which it came and see a pre-recorded video or message from the farm.⁷⁸

⁷⁵ Loseke, Ryan and June. Personal Interview. “Cow-Calf purchases.” 13 August 2019.

⁷⁶ “IBM Food Trust.” *IBM*, www.ibm.com/blockchain/solutions/food-trust.

⁷⁷ “Blockchain Based Seafood Traceability & Data Ecosystem.” *Fishcoin*, fishcoin.co/.

⁷⁸ Nelson, April. “Honeysuckle White® Expands Thanksgiving Traceable Turkey Program, Continuing Its Commitment to Food Transparency.” *Cargill*, 1 Nov. 2018, www.cargill.com/2018/honeysuckle-white-expands-thanksgiving-traceable-turkey-program.

Specific to beef, numerous organizations have reported working on integrating blockchain into their beef supply chains. One of the key groups doing this in the United States is Wyoming's BeefChain.

BeefChain states their mission as creating “a new ‘rancher centric’ supply chain utilizing blockchain technology to recapture the value now realized by third-party feedlots and processors.”⁷⁹ They have goal to create an end-to-end system of blockchain enabled supply chain management that they call “Rancher to retail”. Importantly, they are developing several means by which they can accomplish this goal by using a viable business model, and their impact is already showing. BeefChain currently has at least 7 partner ranches and over 1600 RFID and blockchain tagged calves, with the first blockchain certified beef set to go on sale in the fall of 2019.⁸⁰

BeefChain has garnered significant, widespread attention in the beef and blockchain worlds and has been able to demonstrate the effectiveness of its idea by using a blockchain enabled system to successfully track shipments of Wyoming beef to Taiwan.⁸¹ The introduction of BeefChain and other, similar systems such as BeefLedger in Australia or the aforementioned Fishcoin brings about the idea there is a suitable, non-governmental business model to develop a blockchain enabled supply chain architecture in the US and perhaps other developed market economies.

Overview of Findings

In brief, this section will reiterate the key findings of this paper, while leaving the recommendations of this paper to the next section. While this paper touched upon many topics related to the integration of blockchain in the beef industry, this comparative analysis yielded its desired results; a breakdown of which issues within the beef industry are shared by the Kenya and the US and to what extent these issues are unique to each beef industry.

Food Safety and Disease Prevention

The first of these issues that is strongly shared across the Kenyan and US beef supply chains is that of food safety. Both countries invest significantly into their respect systems to ensure food safety and the prevention of disease, and in both countries, there is significant interest in using blockchain to help mitigate some of the risk of food safety issues. Despite the stronger regulations and higher food and animal safety standards in the US, the threat of animal-borne disease or contaminated meat is still very real, and when lapses in either disease or food safety does occur, it is incredibly costly. The idea of using blockchain to mitigate food safety risks is widespread, but a critical mass of adoption by producers and intermediaries is needed for its successful implementation.

⁷⁹ “About Us.” *BeefChain*, 2018, beefchain.com/about/.

⁸⁰ Jennings, Rob. Phone Interview. “Permissioned Blockchains.” 8 August 2019.

⁸¹ “First-Ever Blockchain Beef Shipment Traced from Wyoming to Taiwan.” *Northern AG Network*, 19 Feb. 2019, www.northernag.net/first-ever-blockchain-beef-shipment-traced-from-wyoming-to-taiwan/.

Information Sharing

The next type of problem that is shared by both the US and Kenya can be generalized as information sharing. The complexity of the beef supply chain also leads to its opacity, stymieing the flow of information to the various parties involved. In both countries, information such as the identity and specifics of the cow, the way it was raised, the data of the beef post slaughter and the pricing information throughout the chain can be affected by this opacity. However, due to the different stages of development of the two systems, the outcomes of improving the flow of information would probably affect the supply chains in slightly different ways. In the US market, this information could be used highly sophisticated breeders, in order to improve their genetic pool for higher quality beef or to ensure the purity of specific breed cattle, such as Wagyu. In Kenya, this information may more simply be used as a means to see where middlemen are taking the biggest cut of money and using this information as negotiating leverage. The flow of cattle specific information would greatly improve both processes and the transparency of pricing in both countries, despite the information being directly used in different ways.

Ownership Records

More specific to the Kenyan beef industry is the problem of ownership records of cattle. While raising cattle is incredibly capital intensive and carries significant financial risk in both the US and Kenya, in Kenya this is comparatively exacerbated. The US has a more developed financial infrastructure as well as sale documentation that allows ranchers and other producers to have proper record of ownership, to then use for financial or insurance purposes. As previously explained however, in Kenya many producers lack even basic proof of ownership of their cattle, making it much harder to use them as collateral or prove ownership for insurance purposes against predator attacks or other incidents. Overall, a blockchain enabled system could act as a more modern means of recording ownership in a verifiable and paperless way that also removes the need for a governmental agency, an especially important point in countries or regions that are more prone to corruption.

Contract Execution

An issue more specific to the US beef industry is that of contract execution. The abuses of the system at the Sale Barn was highlighted and more generally the slow pace of payment and contract execution leads to unnecessary waiting, fees, and liability for the various owners of the cattle throughout the cycle. While a smoother contract execution would obviously be an improvement to any beef industry, it is more applicable to the US here, as the US has a non-cash system that exacerbates the issues as well as simultaneously having the willingness to pay to remove certain transaction fees that already exist in the system. This idea too, would require much more in depth use of blockchain technology to execute smart contracts or even incorporate a cryptocurrency-based transaction means, and creating buy-in for such an overhaul of the process would take significant time and resources.

Recommendations of Blockchain implementation

The possible benefits of blockchain being integrated to the beef supply chain are well documented throughout this paper. This section aims to quickly address the pragmatic ability for how such integration could come about, and how this may vary along the lines of our case countries of Kenya and the United States.

Private Sector

The first general avenue of possible integration of blockchain to the beef industry comes through private sector innovation. As with BeefChain and other examples, there is significant interest by various private companies and organizations who see integrating blockchain as a profitable business opportunity. The global beef industry is incredibly large and a company that can offer an integral service to improve the industry stands to possibly make a lot of money in the process. The issues that private companies attempting to bring this integration face are two-fold, encouraging buy-in to share information from all of the intermediaries involved and finding a sustainable business model that creates value for the various parties involved.

With information sharing, a problem to implementation lies with the fact that not all parties are hurt by opacity in the supply chain. For example, imagine a US feedlot who has discovered that the calves they purchase from a specific cow-calf ranch routinely earn the USDA “Prime” certification, earning them more money when they sell to the meatpacker. By passing this information along to the cow-calf operation, the operation would likely use this information to demand a higher price, creating a disincentive for the feedlot to pass along the information. While a permissioned blockchain system would allow for the parties involved to have some control over who can access specific or proprietary information, there still is a major hurdle to convincing the parties involved to share information. Theoretically, if parties agree to share information both ways then these disincentives are partially mitigated. Additionally, if one party believes that their information is particularly valuable, the sale of the data, separate from the animal, could possibly be arranged.

Even if buy-in to share information is established, for a private sector of blockchain integration to the beef industry to work, there must be a sustainable revenue model to fund such a system. Developing, building, maintaining, and managing a blockchain enabled beef supply chain system would be capital intensive not only in the development but also in marketing and maintaining of the system that would be required. Several ideas for sustainable revenue models have been proposed by various companies and individuals, each with their own merits and drawbacks. Perhaps the most plausible system would be to charge a very small fee (perhaps from a few cents to even fractions of a cent) in order to access the application programming interface (API). This would spread out the costs across the various stakeholders in the supply chain and could encourage more use of the system in developing beef industries like Kenya than a heftier subscription service.

For a private sector innovation in this space to occur, there must be significant access to capital for the development of such a product. Additionally, a regulatory environment that is conducive to allowing and securing the right of private companies to hold, transmit, and share this data is also requisite. Both Kenya and the United States may possess these qualities, but the access and pairing of capital, technological knowledge, and a more developed beef industry has enabled the United States to start as a hub for this innovation.

Public Sector

A second possible avenue for the integration of blockchain to the beef industry is through governmental regulatory action. In both Kenya and the United States, various governmental

agencies are already tasked with the important job of regulating the cattle production and slaughter industries. For these agencies, it seems within their prerogative to ask the parties involved within this supply chain to comply with a new and more accurate and efficient system, especially one that could reduce the risk of contamination and disease.

However, even if a governmental agency had the ability to institute such a system, there are several issues that could arise. Firstly, governmental agencies themselves may not want to institute such a system. High costs of implementing and maintaining such a system may be politically unpopular, regardless of if it is paid for by fees from those in the supply chain, or through broader increase in taxation. Additionally, governmental agencies more generally have been hesitant to use blockchain integrated systems, as such a system wrests control from their agency's control to a decentralized and hard-to-regulate system. From the producer and meatpacker side, there is also push back to any increased regulation of the beef industry, especially in the US.

In Kenya this governmental implementation of a blockchain supply chain system may be more realistic for a few reasons. Firstly, widespread distrust of the meat industry by the general public due to the aforementioned doctoring of meat with sulfites⁸² may lead to this type of proposal garnering widespread public support, making the move easier politically. Additionally, as compared to the US, the regulatory environment in Kenya is weaker, meaning that implementing a blockchain integrated supply chain mechanism for ensuring food and animal safety would not be seen as unnecessary or redundant. A second factor that could contribute to governmental implementation being more viable in Kenya is the governmental ownership of the Kenya Meat Corporation (KMC). With the government being directly involved in the supply chain as a main buyer, slaughterer, and seller of beef, they could first help implement blockchain systems into their own supply chain. This would allow them to build out this blockchain infrastructure without creating a strict mandate or regulation and easing the beef industry into the adoption of this technology, making improvements to their own internal system throughout.

The merits and benefits of blockchain integration to the beef industry are obvious, but its integration requires significant resources and money to make it work successfully. While a private sector method of introducing blockchain to the industry would perhaps align with the "spirit" of using a distributed ledger system, another possibility that eventually both the governmental regulators and private parties could use blockchain enabled systems to share data with each other and improve the efficiency even further.

Conclusion

In conclusion, the beef industry is an incredibly complex and interconnected industry in both Kenya and the United States. Despite the difference in the advancement of these two beef industries, the inefficiencies that lie within both of these countries are largely shared. These inefficiencies don't just hurt those who are working within the beef industry, but they can create adverse market and even health conditions that affect a much larger cross section of society. A

⁸² Ngila, Faustine. "NGILA: Use Blockchain to Save Kenya's Meat Industry From." *Daily Nation*, Daily Nation, 22 July 2019, www.nation.co.ke/oped/opinion/Use-blockchain-save-Kenya-meat-industry-/440808-5206040-vapjwk/index.html.

technology that is seeming unrelated to beef, blockchain, may be the infrastructural base of supply chain management systems that help to alleviate some of these inefficiencies; in the process creating positive economic and social impact extending well beyond the beef industry.

This paper recognizes the newness of blockchain integration into the beef industry, and also the potential that wholistic blockchain integration to the beef industry may not be viable until both blockchain and cattle technology has improved significantly to support this change. This paper should however contribute to this conversation by bringing in the element of a comparative analysis of two very different beef industries and how they both may benefit from the integration of blockchain introduction. Despite all of the interest in this topic, blockchain applications for the beef industry more holistically still remains a relatively under-research topic. More research into the viability and methods of implementation for the integration of blockchain to the beef industry remains to be completed.

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