Describing the cull sow and cull hog market networks in the US: A pilot project

Final Report for Swine Health Information Center Project #16-275 SHIC

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Key Findings

- Capturing detailed information about cull swine shipment locations and farms of origin at the time of harvest was both feasible and practical.
- Collecting market movement data between the farm of origin and the last shipping location to the plant proved to be impossible.
- The majority (86%) of culls that entered the harvest plant did so from a terminal collection point that was in close proximity to the source farm.
- About 14% of culls that entered the terminal market traveled more than 240 kilometers from the source farm to the terminal collection point. Of these 14%, 17.7 % or 2.5% of all culls traveled 5 times as far to the terminal collection point from the source farm than they did from terminal collection point to terminal market. We hypothesize that these culls moved between collection points prior to arrival at the harvest plant.

Project Objectives from Proposal

The overall objective of this line of investigation is to describe the scope and complexity of cull sow and cull pig-marketing channels. There is little objective data available to allow the industry and regulators to make informed decisions about how to respond to animal health emergencies. The project described here is a small pilot project to determine if it possible to collect the data needed to describe cull marketing channels in the US and outline a preliminary method for data capture and analysis to describe the US cull marketing system.

1. Determine if the data that is needed to estimate the complexity (number of primary, secondary and tertiary sources, connections between those sources, geographic distribution of those sources and time in the market network) are available in a format that will allow for analysis.
2. Define for a one-week period of time a) one cull sow terminal market (harvest facility) and b) one cull market pig terminal market the number of both collection points and primary sources (farms) of animals for that facility.

3. For each market (A and B) define the network relationships created from animal movements) using network statistics for that market including Farm-Market; Farm-Collection point and Collection point-Collection point interactions.

4. Define, to the level of a zip code, the geographic market basin for each terminal market.

5. For a subset of animals estimate, the time spent in the marketing network from farm to harvest.

Methods

Data was captured from a single cull swine terminal harvest market over a one-week period in the spring of 2017. We collected the Premise ID tag from each animal and a copy of the bill of lading from each shipment (shipment lot) into the plant. Each ID was associated with a shipping lot (bill of lading) and therefore a location of shipping origin. Ninety point four percent of all culls harvested that week were identified to their premise of origin and shipping location.

For each premise ID, the location of the premise was identified by gathering the street address from publicly available records. The street address was converted to geospatial coordinates. Site locations were confirmed using satellite images on Google Maps. A similar process was used to identify the geospatial coordinates of all the origin locations for culls that arrived at the terminal market based on the address listed on the bill of lading.

Source farms were defined as an individual premise ID and terminal collection points were defined as the last point of collection animals were at prior to arrival the terminal market. For each animal in the study, multiple straight-line distances were calculated using the geospatial coordinates identified for each of the source farms, terminal collection points and the terminal market. The R statistical package was used to perform all calculations.

Results

Harvest Data Captured: We collected data 90.4% of animals harvested during the collection period. These culls originated from 297 SOURCES. All that arrived at the plant were at an off-farm point of concentration, terminal collection point, as their last location prior to arrival. Hence, no culls arrived straight from the source farm to the terminal market without contact with another point of concentration. Culls were harvested from 21 states and Canada. Shipping locations were in seven different states in addition to Canada.

Data Availability: The key objective of this study was to determine if the cull swine-marketing network that exists in the US could be accurately described with the available data. We determined that capturing individual premise IDs at the terminal market is both possible and data yields (percent of animals identified) are high enough (90.4%) to allow reasonable conclusions to be drawn about the source farms of animals into a given terminal market. The data, with current techniques is very labor intensive to capture but the quality is good.

In addition, it was both easy and possible to capture the last location that individual culls were at prior to arrival at the terminal market. However, it proved impossible to track culls beyond the last location prior to the terminal market. The inability to capture this data precluded our ability to describe and understand the network of movements between collection points in the US cull swine marketing system. We believe that there are multiple reasons for the inability to obtain this data. First and foremost, it is largely paper based and is distributed across the network of buying stations meaning that gaining access would require significant effort on the part of the data owners, which in their perception, had little value to them. Secondly, and significantly, data of this nature is viewed as a providing a key competitive advantage and sharing that data with anyone could reduce one market participant's advantage over their competitors. As in most markets, information is power. The harvest plant supported the project given maintenance of confidentiality.

Geospatial distribution of SOURCES: To look at the distribution of source farms, we decided the most effective method to describe their distribution was as national or local. Local was defined as the minimum market radius from the terminal market needed to meet the terminal market's yearly capacity. The number of culls available in an area was determined using the USDA census survey's estimation of breeding inventory by county, and an assumed 50% yearly cull rate. At the assumptions stated local is defined in this study as an area centered at the terminal market with a radius of 250km. 23.5% of culls derive from source farms in this local area and 43% of terminal collection points represented were located locally as well. This proves the cull network is national in its distribution, and that culls are moved across large geographical regions to terminal markets.

Stateline data on Movement of Cull: To futher investigate the large national region that these culls move from source farm to terminal market the number of stateliness crossed as depicted by a straight line between 2 points was calculated. The results were then expressed in the box and whisket plot seen in Figure 2. The median number of statelines that culls move across between source farm and terminal collection point is 0. This supports the data above that states that 86% of culls arrive to collection points locally. The median of both

statelines between terminal collection point and terminal market and total statelines crossed is 3. 86.9% of all culls cross at least 1 stateline moving from source farm to terminal market

Movement of Culls from Source Farm to Terminal Collection: As seen the source farms represented are national in their distribution, and the cull swine network is complex, vast and national. However, little is known about how these culls move from the source farm to terminal collection points. As seen in Figure 2 the median statelines crossed differ between the source farm to collection point and the rest of the network. To further investigate how culls move in this part of the cull market network the distance between source farm and terminal collection point of culls was calculated. An outlier analysis was performed on the data and determined that culls traveling more than 240km were outliers in the network. Distribution of these distances were plotted (Figure 1.) 86% of culls originate within 240km of the terminal collection points. 14% of culls travel distances greater than 240km to the terminal collection point. We hypothesize that, through analysis of both outliers and distribution, culls originating more than 240km from terminal collection point at subject to contacts with multiple collections points prior to terminal market.

Discussion

We believe this to be the first data set collected that allows for this level of detail in describing cull sow movement after leaving the farm until harvest. While it is limited in both geographic and temporal scope, its granularity allows for unique insights into animal movements and strongly suggests that the capture of additional data over both time and geographic location would be valuable in understanding the risk of disease transmission though cull marketing channel in the US.

Identifying 90.4% of culls over a short time period demonstrates that tracking culls through the PLANT is a realistic method to capture the complexity of the cull system. These data suggest that a large percentage (86%) of the culls harvested in this period originated from a collection point that was in close proximity to the source farm. These interactions are deemed to be primary interactions, meaning that it is of high likelihood that the culls moved direct from source farm to terminal collection point. A small but significant number of sows (14%) originated from source farms greater than 240km from the terminal collection point and 2.5% of all sows traveled 5 times as far from the source farm to the terminal collection point as from the terminal collection point to the terminal market. We believe that these culls represent animals, which had contact with multiple collection points during their time in the marketing channel. We estimate that for this week between 2.5 and 14% of the culls harvested had contact with multiple collection points after they left the source farm.

The data we captured represented 297 source farms from 21 states and Canada. 23.5% of culls originated from source farms in a local region extending 250km from the terminal market. We believe that this suggests that the cull swine network is national in scope and the location of the terminal market is not a good predictor of the farms where the culls originated. To further support the notion of the market channel being national in scope, 86.9% of culls crossed at least 1 stateline on the way to the terminal market.

With the introduction of source for effective disease transmission, 2.5-14% of culls moving within collection points, and the national scope of the network, these data further suggest that culls, as was suspected for PEDV, could be an efficient means of transferring novel diseases across large geographic areas., Compounding this risk is the use of trucks to haul other loads of both swine and other species with none to minimal cleaning and decontamination between loads as the common perception is that these trucks are only hauling terminal animals and pose insignificant risk to other farms.

Future Work

This small data set suggests that a larger dataset would increase our understanding of disease transmission risks posed by the cull swine movements. Larger datasets lend themselves to reveal more about not only what was deemed difficult to understand in this study, i.e. movements between collection points, but would allow for insight into how temporal, geospatial, and economical changes could affect movements. Investigations into these complex effects would allow for a fuller understanding of the dynamics of the cull swine network.

The challenge to capturing a larger data set is the amount of labor required to capture national premise id tag data in the plant and convert it to an electronic format for analysis. We have identified a technology that will allow us to use images of tags and digitize them though imaging processing software. The software normalizes that tags orientation and size in the image then through a bit of logic identifies and records the 7 digit unique premise id number. Current beta tests of the software on images of tags that were removed from sows suggested the technology could be viable and further evaluation of its application in the plant is warranted.

In conjunction to the text recognition software, we are currently beta testing low cost hardware that could be installed into plants allowing us to in real time capture and process images of tags. The hardware is composed of multiple cameras that allow for a large high definition field of view to ensuring that even with variations of the tag's orientation in a XY plane capture of the ear tag data. After the software processes the images, the device can be equipped to upload the data to a secure database in real time.

This approach will allow us to capture data in multiple plants over an extended amount of time, facilitating the development of a dataset that is more representative of both the geographical distribution of markets in the US, temporal changes and economic effects in the cull sow movement patterns. In addition, we believe that we can scale the technology to run in plants under commercial conditions with a low cost of deployment and operation to give both regulators and the industry real-time information on cull animal movements in the case of a novel disease introduction, allowing well informed decisions to be made.

Figures

Figure 1: Distribution of the number of sows delivered to the plant by the kilometers that the source farm was from the terminal collection point.

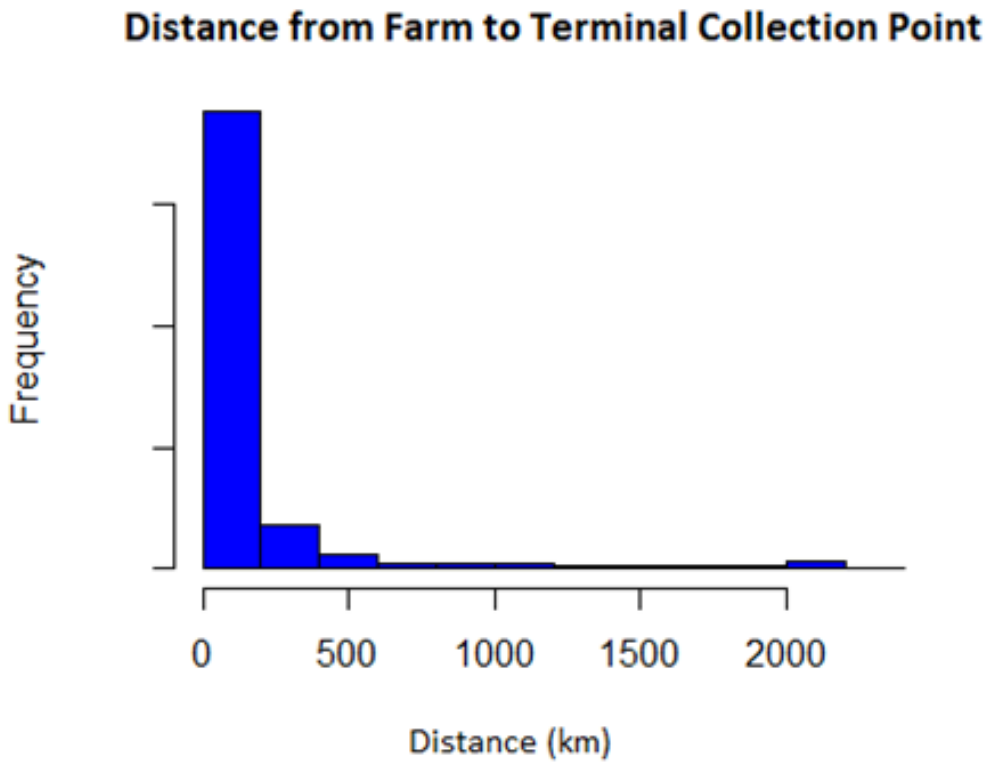
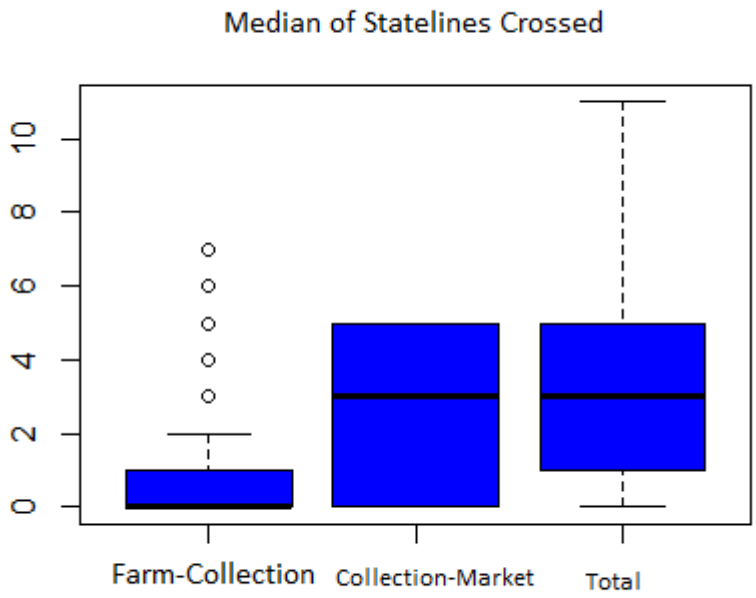


Figure 2: Plot of Statelines crossed moving between points in the network.



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Project Summary:

What is the range of locations of sows that enter a slaughter plant? How many stops along the way do they make? How long do they remain the slaughter channel? Currently there is little data to investigate such questions allowing the industry and regulators to make informed decisions about how to respond to an animal disease outbreak. This project set out to collect data from a harvest plant to see if such information could lead to answers to those questions allowing the industry and animal health officials to better make decisions to prevent and control animal health emergencies.

In this study, data was captured from a single cull harvest plant, over a period of one week during the spring of 2017. We collected Premise ID tags of the culls as they moved through the plant and grouped them by shipping lot. This allowed for the final point of collection to be identified for the purposes of this study. The premise IDs were then cross referenced against a database containing origin information for each unique premise ID to identify the cull's proposed farm of origin.

In total, we collected premise data on 90.4% of the culls that moved through the harvest plant that week. The animals originated from a total of 297 unique source farms. Sows originated from farms in 21 states and Canada. To determine whether movements to plants derive locally or nationally the distances between origin farms and plant were calculated. We defined the local region for this plant as the radius needed to meet the plant's capacity at an industry standard 50% cull rate per year. USDA census surveys where used to calculate the breeding inventory of this area at a county level, and determined a 250km radius sufficient to provide the culls to meet capacity. With this in mind, 23.5% of culls originate from farms in the described local region and 43% of final collection points also reside within 250km of the plant. This depicts nature of the cull movements in the market network as national.

The data above presents information on how the cull network begins and ends however little is known about how culls move through collection points. To learn more about how these culls move after leaving the farm and before arriving at the plant, a simple distribution of the distance between the farm of origin and the final collection point was graphed. We also screened the data for statistical outliers and found that culls originating from distances greater that 240km from the terminal collection point were classified as outliers in the network. The majority of culls (86%) originate less than 240km from the final collection point. This interaction is deemed to be a primary interaction meaning that it is very likely the culls moved direct from the farm of origin to the final collection point. 14% of the culls travel a distance greater than 240km to the terminal collection point. Of these 14%, 17.7 % or 2.5% of all culls traveled 5 times as far to the last point of collection from the farm than they did from collection point to plant. We hypothesize that 2.5% to 14% of culls moved between multiple collection points prior to arrival at the harvest plant.

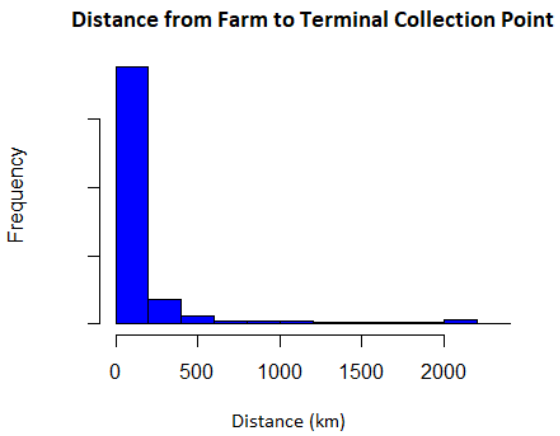

Figure 1: Distribution of sows by the kilometers traveled from the farm of origin to the terminal collection point.

We believe to be the first data set collected that allows for this level of detail in describing cull movement from farm until harvest. Although or study has limitations in both the size of dataset and limited timeframe, we believe it provides a unique insight into animal movements and serves as a platform for further work such as this, using larger sets of data to be completed. A better understanding of how culls move throughout the network may provide more detail about disease transmission in the cull market in the US.

Identifying 90.4% of culls over a short time period demonstrates that tracking culls through harvest plants is a realistic method to capture the complexity of the cull network. Although only 2.5%-14% of culls are believed to have moved between multiple collection points prior to harvest. We believe that this is significant and suggest, as was suspected for PEDV, that culls could be an efficient means of transferring diseases across large geographical regions. Being able to

understand the way not only sows but diseases move through the slaughter chain holds great value in making the correct decisions to effectively control and prevent disease outbreaks, and why further work must be completed to effectively and efficiently track culls sows through harvest plans to prepare for such an event.