

Spatial and Temporal Analysis of Farmers Markets and Their Regional Farms in Philadelphia, PA

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Local food systems often reflect the larger food system's dependency on farms to create a sustainable system. Understanding the distance traveled by farms to farmers markets is important for understanding how the local food system has shaped areas like Philadelphia. The purpose of the study is to evaluate the relationship between regional farms and urban farmers markets over the past decade in Philadelphia. This study focuses on the spatial distribution of urban farmers markets, regional farm suppliers, the distance regional farmers have traveled, and how that has changed between 2009 and 2019. A 2009 dataset obtained from Dr. Peleg Kremer was used as a baseline and was updated over the summer and fall of 2019. The distances between farms and farmers markets were calculated using proximity tools in ArcGIS, a mapping-based software. These distances were placed into categories based on farm products sold like fruits, vegetables, dairy, protein, oils/sweets, and miscellaneous. Results show there has been a change in distance traveled by farms to farmers markets. However, there is no direct connection between farm products and mileage. This study may not show a product influence, but it has uncovered factors like product preferences and Pennsylvania counties trends that influence regional farm supply in Philadelphia's local food system.

Introduction

Farmers markets are an important part of local food systems due to the expanded accessibility they offer city residents to fresh, regional produce. (Hinrichs, Lyson 2007, 65). Philadelphia has a developing farmers market network, which is influenced by farmers and their decisions. Farmers' decisions to participate in farmers markets are determined by location, market forces, laws, and regulations, along with other variables (Vitiello, Brinkley 2014, 98). Understanding the spatial structure of regional food production, the ties to local farmers markets, and changes over time can help assess the stability of direct food supply to the city.

Kremer and DeLiberty (2011) discuss the relationship between travel distance and regional farms. Like this research, they use spatial analysis in the form of directional distribution to find the directional trends in regional farmers that travel to Philadelphia (Kremer, DeLiberty 2011). They map the average distance of farmers that travel into Philadelphia among the immediate region, 50-mile, and 100-mile radius (Kremer, DeLiberty 2011). The 2009 baseline used in my methods section was first published in this article, which offers insight on an earlier analysis of Philadelphia's food system. This publication can be utilized to compare and contrast how farm distance in 2019 has changed in terms of potential new farm participants and the average travel for regional suppliers.

To understand the local food system of Philadelphia, food systems history acknowledges Philadelphia's supply capacity for regional farm

suppliers. Vitiello and Brinkley (2014) emphasize the remarkable changes to food systems as American cities have developed over centuries. Their article divides sections of early food systems in European colonization of America to food systems today. Today's general planning includes farming within city limits and farms outside the limits providing to city residents who still lack fresh produce (Vitiello, Brinkley 2014, 106). Due to "early-twentieth-century worries that the supply chains feeding cities were becoming less proximate..." (Vitiello Brinkley 2014, 104) farmers markets were used to combat decreasing local food supply. The history of local food system planning shows how Philadelphia's sourcing from beyond city limits is reflective of improvements to its local food supply.

For local food system planning, Philadelphia, a city with a historic presence of urban agriculture, must factor in the supply of local food within the city. Philadelphia's urban farms seek to provide to communities experiencing poverty or food insecurity (Meenar, Hoover 2014, 145). Meenar and Hoover (2014) examine urban agriculture with Philadelphia as the case study. Philadelphia's urban agriculture movement also focuses on how these urban farms interact with both farms that come into the community and farmers markets. Urban farms in Philadelphia can affect the need for the farms outside the city, particularly depending on the supply and demand for certain produce (Meenar, Hoover 2014, 141). Consequently, the study serves as an explanation for why there may be an appeal to supply certain product categories over others.

Schafft (2010) explains how other programs

and initiatives can affect local food systems. Farm-to-school programs have been almost as popular as farmers markets to attract farms to cities' local food systems. However, many schools who buy local food do not necessarily call themselves farm-to-school programs. (Schafft et al 2010). These schools were buying local produce from wholesale and retail avenues. Elements like audience have impacted farms' sales preferences for the Pennsylvania area (Schafft et al 2010). Farms will be more willing to provide in a local food system if they have favorable reception from the local community, whether that be from schools or farmers market customers.

Due to Schafft's (2010) note of farm preference for certain areas, I decided to research the appeal of farmers markets to regional farmers. Payne (2002) records how crucial farmers markets are for farm sales. Farmers markets provide opportunities to sell directly to customers which is "...the only access to customers that many small- and medium-size farm operations have." (Payne 2002, 173) Small and medium farms view farmers markets as one of the only ways to increase profits since they are unable to meet wholesale production standards. Payne (2002) concludes "...farmers' markets are a growing marketing tool for farmers" (175) due to their fostering of direct interaction with their consumer base. Regional farms are able to build their customers while maintaining their production scale, which makes farmers markets unique opportunities that small and medium regional farms best satisfy.

A benefit for regional farms is farmers markets have shown to increase consumer accessibility the longer they have time to develop (Young et al. 2013). Young's (2013) article shows accessibility increases for low-income Philadelphia residents at farmers markets. The Food Trust, a Philadelphia farmers market organizer, implemented a coupon incentive program called Philly Food Bucks. This program offered two-dollar coupons to Supplemental Nutrition Assistance Program (SNAP) eligible customers for fruit and vegetable purchases at farmers markets. These programs were concluded to be extremely successful, with SNAP purchases increasing "...more than 300% from \$12,431 in 2009, before Philly Food Bucks, to \$52,405 in 2011, after 2 years of the Philly Food Bucks program." (Young et al. 2013). Higher profits in farmers markets incentivizes regional farms to travel for more profits while also expanding the consumer population.

Recognizing the Philly Food Bucks' prioritization of fruits and vegetables, my final source was based on farmers markets' responses toward certain product categories. Lucan (2015) expresses that fruits and vegetables were the most favorable products for farmers markets. From the New York study, "across all FMs, fruits and vegetables accounted for less than 2/3 of

all food items overall..." (Lucan et al. 2015, 24) at 65.7 percent. Though the study was done in Bronx County, New York, it is worth comparing the location to a nearby city like Philadelphia. Analyzing the history of food systems, farm distance analysis, and farm characteristics in the literature, I conclude that studying the local food system and the relationship between farms and farmers markets can help increase understanding of the changes in Philadelphia's food system.

Research Goals

For this project, I examined the spatial distribution of farmers markets in Philadelphia and the regional farms that supply them. I also analyzed the distance and direction that regional farmers travel to reach farmers markets in Philadelphia. Further, I wanted to research the types of farm produce arriving to farmers markets in Philadelphia. The relationship between distance and farm product type was investigated to determine if the farm's decision to travel was dependent on farm product. Finally, I observed changes in farmers markets and farms over the time period of 2009-2019.

Methods

A baseline Microsoft Excel database containing the lists of farmers markets and regional farms that traveled to Philadelphia's farmers markets in 2009 was obtained from Dr. Kremer. Over the summer of 2019, the lists of farmers markets and regional farms were updated to represent the current farmers markets in Philadelphia and regional farms. The update of the data was accomplished through Internet searches, published inventories, phone calls, and emails.

Philadelphia's farmers markets and regional farms were divided into three categories. The first category was named "Old" and included 2009 farmers markets that were no longer open. The regional farms in the "Old" category were either shut down or no longer sold to Philadelphia's farmers markets in 2019. The second category was named "No Change". This category included farmers markets that were open in 2009 and remained open in 2019. The regional farms that were marked "No Change" were selling their products to Philadelphia's farmers markets in both 2009 and 2019. The third category was "New" and included new farmers markets in 2019 that did not exist in 2009. The regional farms categorized as "New" were farms that sold to farmers markets in 2019, but not 2009. The farmers markets and regional farms were organized by their assigned category in a Microsoft Excel sheet that contained the coordinates for each location.

The 2009 and 2019 farmers markets and regional

farms' coordinates were entered using ESRI ArcMap 10.7, a mapping software. Distance analysis was calculated using the "Generate Near Table" tool. The "Generate Near Table" tool produces distance measurements between regional farms to farmers markets using coordinates. Since the coordinate system used was in meters, these travel distances were converted to miles. A matrix, which shows the distances each farm travels to reach farmers markets, was assembled. The matrix also averaged the distance each farmer traveled to farmers markets if they traveled to multiple farmers markets. The miles that each farmer traveled to their farmers markets were visualized using the "Generate XY to Line" tool. The "Generate XY to Line" tool produces lines from the location of a regional farm to their farmer market(s) location(s). The "Directional Distribution" tool was also used to find the directional trend of the locations of regional farms that provide to farmers markets.

A table was generated to produce the count of farms in each product category for the years of 2009 and 2019. This table was produced using the Microsoft Word "Insert Table" feature. Multiple farms sold produce in more than one product category and were added to every product category they sold under. Finally, a box plot was created in Microsoft Excel for the years of 2009 and 2019, displaying the distribution of travel distance. The dots outside of the box plot represent the outliers for each year, without a visual distinction in product category.

The food group categories were grouped according to the USDA's Dietary Guidelines ("USDA Food Patterns" 2019). Fruits, vegetables, dairy, protein, and oil/sweets were the principle product categories for the farms. These food groups were also accompanied by a group named "Miscellaneous", which consists of herbs and plants like flowers and Christmas trees. The miles traveled for each product category were averaged for the 2009 and 2019 years. The overall average of all products' travel distances were calculated for both the 2009 and 2019 years.

Results

Figures 1 and 2 show how farmers markets and regional farms have changed in Philadelphia over the 2009 to 2019 decade. There has been a 13 percent increase in farmers markets in Philadelphia, but approximately a 9 percent decrease in regional farmers traveling to Philadelphia. Figure 3 visually represents the travel distance from farm locations to Philadelphia farmers markets. In 2009, regional farmers traveled an average of 49 miles to Philadelphia's farmers markets. In 2019, regional farmers traveled an average of 53 miles to Philadelphia's farmers markets. The miles traveled by

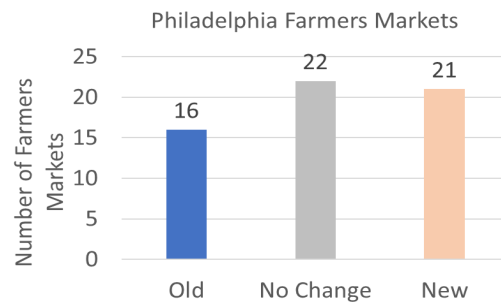


Figure 1: Bar graph showing the number of Philadelphia's farmer markets by category.

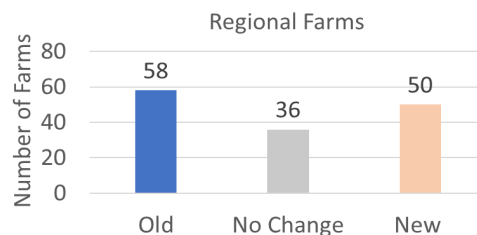


Figure 2: Bar graph visualizing the number of regional farms at Philadelphia's farmers markets.

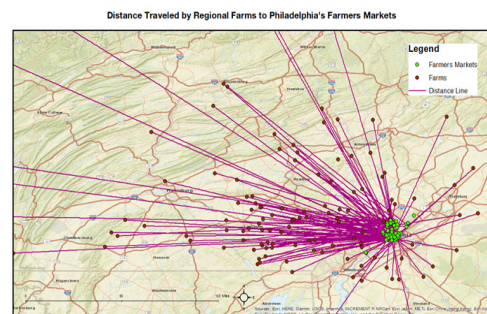


Figure 3: Map displaying distance traveled by regional farmers to Philadelphia's farmers markets. Produced from Esri ArcMap's XY to Line tool. The tool shows a visual representation of each regional farmer's distance to the markets to which they currently sell or to which they previously sold in Philadelphia.

farmers for each product category are shown in Figure 4.

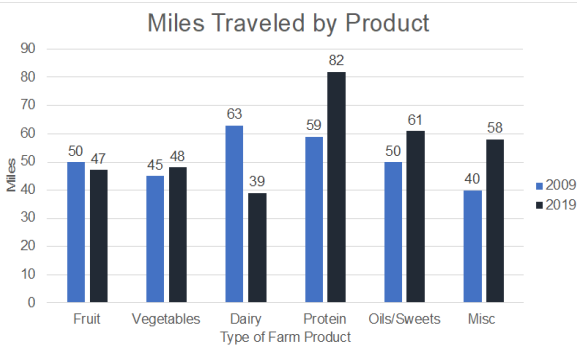


Figure 4: Bar graph depicts the miles that regional farmers travel based on their product category or categories. These are further separated by farm mileage in 2009 and 2019.

	Fruit	Vegetables	Dairy	Protein	Oil/Sweets	Misc.
Number of Farms (2009)	43	56	15	19	21	20
Number of Farms (2019)	42	48	8	15	13	19

Figure 5: Table exhibiting the number of farms per product category in 2009 and 2019.

Figure 5 exhibits the number of farms per product category for the years of 2009 and 2019. The numbers of fruit and vegetable products were more than double those of all other product categories in both the 2009 and 2019 years.

Figure 6 shows the distribution of regional farm distance. All product categories had outliers in the 2009 data. All product categories except for dairy had outliers in the 2019 data. The number of outliers in each product category varied for both the 2009 and 2019 data.

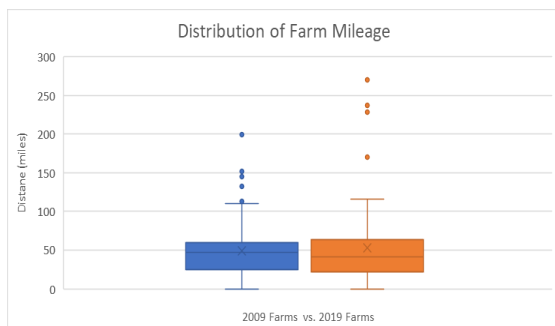


Figure 6: The blue box represents the 2009 farms while the orange box signifies the 2019 farms. Both dots in each color show the outliers in farm travel distance.

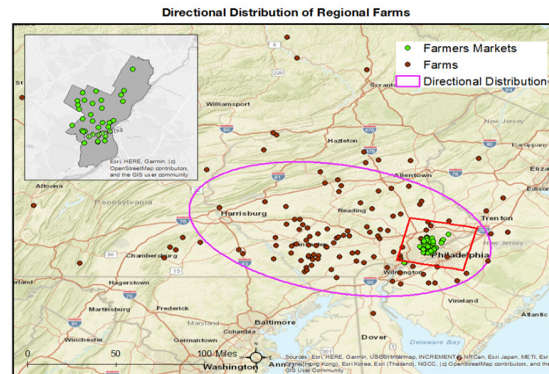


Figure 7: Map of Directional Distribution of Regional Farms created using Esri ArcMap. The pink circle shows the direction distribution, with an inset map to further show the farmers markets in Philadelphia.

Figure 7 indicates that farms west of the Philadelphia city limits have a trend of providing to Philadelphia’s farmers markets. These farms are enclosed by a pink circle on the map. Further investigating the data, a majority of farms were from Lancaster and Chester counties, at 40 percent. Including Philadelphia with those two counties, more than half of regional farmers come from three counties, at 51 percent. Pennsylvania regional farms make up 84 percent of farmers that travel to Philadelphia’s farmers markets.

Discussion

The results suggest that product type and farm miles do not have a relationship because all product categories were impacted by outliers in the data. The number of farms per product category was also noteworthy in the ways that outliers affected the category mileage. The fruit and vegetable product categories were closest to the average mileage because they had larger populations to maintain the 40 to 50 range mileage despite outliers. Additionally, their outliers were in smaller ranges, mostly in the 100s. However, the outliers in the dairy, protein, oil/sweets, and miscellaneous product categories have a greater range of miles. The population ranged from 0 to 270 miles in the dairy, protein, oil/sweets, and miscellaneous product categories with outliers. Additionally, these categories had smaller numbers of farms, which increased the weight of each farm’s mileage when calculating the average. Therefore, results were misrepresented from outliers and a lack of farms to maintain a normal distribution. A resolution to the outlier problem could be to remove the outliers, but it would have to be noted that not all farmers that travel to Philadelphia are included.

However, there is a clear bias for certain categories like fruits and vegetables that does not pertain to travel distance. Figure 5 displays the contrast between the numerous fruit and vegetable farms and farms that sell other products. As discussed previously, customer accessibility has expanded through programs like Philly Food Bucks (Young et al. 2013). This accessibility is particularly geared toward fruit and vegetable products. Fruit and vegetable products are also producing a majority of the revenue, making it appealing for fruit and vegetable farms to participate in Philadelphia's farmers markets despite travel distance (Young et al. 2013). As a result, farmers markets in Philadelphia include far more fruit and vegetable farms, likely due to profit potential and greater accessibility.

The results also demonstrate from which regional farms Philadelphia's farmers markets are most likely to source. Interestingly, Kremer and DeLiberty's (2011) 2009 baseline concludes, "42% of the farms come from only two Pennsylvania counties- Lancaster and Chester Counties." In 2019, Chester and Lancaster counties have made up 40 percent of regional farms. These two counties remain critical regional suppliers for Philadelphia's farmers markets a decade later. A striking difference in the decade is the presence of Philadelphia urban farms in its own farmers markets. The 51 percent majority, including the two other counties, shows an expansion in its own city and Philadelphia's priority to include its own farms in the markets. (Young et al. 2013) Philadelphia's farmers markets rely on sourcing from Lancaster, Chester, and Philadelphia counties. Therefore, the turnout of farmers markets is more reliant on county presence, rather than product category.

The influence of Chester and Lancaster counties poses the question: Why are farmers from these counties so willing to come to Philadelphia's farmers markets? Future studies could analyze how much of the change in regional farms is due to other factors, besides product type, that influence farmers' willingness to travel. This would be specifically for the old farms that are still open and the new farms that existed in 2009. Over the years, farmers and drivers to farmers markets have changed for many farms (Vitello, Brinkley 2014, 92). New decision-makers can influence a farm's presence at farmers markets. Expansion in farms could also lead to a greater willingness to travel due to extra produce and a need for greater profits. Overall, there are many factors that were not evaluated that could clarify why farms are more or less willing to travel to Philadelphia's farmers markets.

Conclusion

There has been both change and consistency in Philadelphia's local food system over the period of 2009 to 2019. Farmers markets have expanded throughout the city of Philadelphia. Their expansion has attracted new regional farms, while total regional farms have decreased. Regional farms have maintained county influence west of Philadelphia's city limits. Though farm product does not influence miles traveled, multiple factors like county trends and preferred products appear to influence farm travel. This has broadened the understanding of the suppliers that make up Philadelphia's local food system and the products that receive the best reception. This research raises questions about other factors that could influence farm travel to farmers markets. It also leaves a thorough explanation of the spatial and temporal components of regional farms and farmers markets in Philadelphia's local food system.

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Dr. Kremer is an Assistant Professor in the Department of Geography & the Environment at Villanova University. Research in Dr. Kremer's lab focus on spatial patterns in social-ecological systems and urban sustainability. Using interdisciplinary approaches to spatial analysis, GIS and remote sensing Dr. Kremer's lab investigates: 1. Mapping and modeling ecosystem service in social-ecological urban systems; 2. Structure of urban Landscapes and environmental Function; 3. Transformation of urban vacant land into public use resource; 4. Urban food systems. Dr. Kremer teaches undergraduate and graduate introductory courses in Geographic Information Systems as well as courses on urban sustainability and the built environment. She holds a PhD in Energy and Environmental Policy from the University of Delaware.