Inferring Temporal Networks Based on Spatial Localization. An application to Organic Dairy Production in the USA: 2002-2015

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1 Introduction

- Given that organic dairy farming is more profitable than conventional dairy farming, why has been the adoption of organic dairy farming slow in the USA?
- What is the logic behind choosing a geographical location to start an organic dairy farming operation?
- Can networks partially explain the geographic location of organic dairy farming in the USA?

2 Dataset

- USDA Integrity Database: Every organic operation is recorded in this database that is open to the public
- The database contains information starting from 2002 when the National Organic Standards became law.
- Each operation includes an address

3 Methods and Results

3.1 GPS location

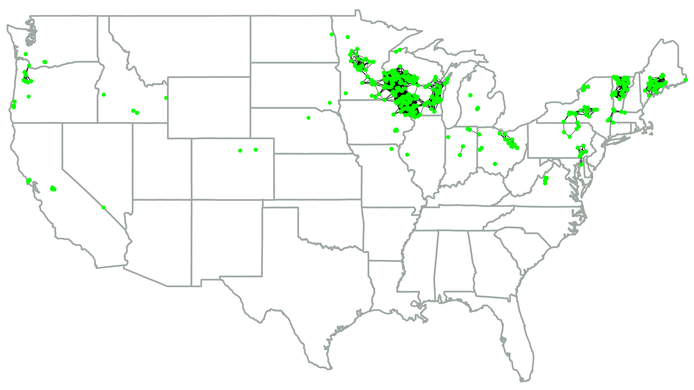
Get GPS Coordinates for each address representing an organic dairy production facility $\longrightarrow GoogleMapsAPI$

3.2 Infer Networks

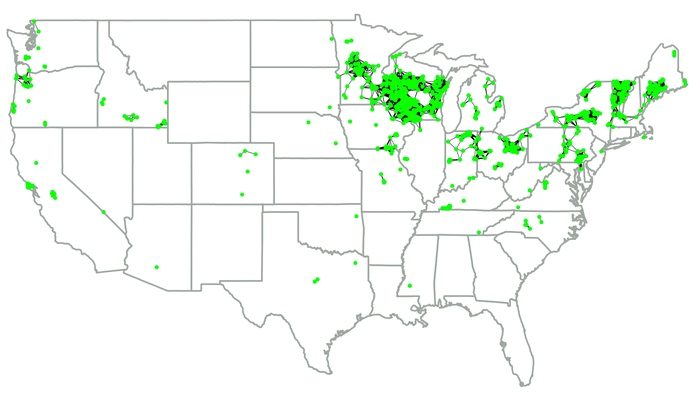
Simulate networks using an algorithm that connects farmer to farmer based on different levels of sociability, distance parameters, and cumulative connections:

Result: 280 Networks: 2002 - 2015, 20 Inferred networks per year.
while *t = 2002 to 2015 (1 year increments)* **do**
  while *p = 5 to 100 (5% increments)* **do**
    if t = *2002* **then**
      - For each GPS coordinate create a 50 mile radius;
      - Connect to other coordinates belonging to t that are inside the radius with probability p;
    else
      If t ¿ 2002 and t ¡= 2015 **then**
      - For each GPS coordinate create a 50 mile radius;
      - Connect to other coordinates inside the radius that belong to $t <= t$ with probability p;
    end
  end
end

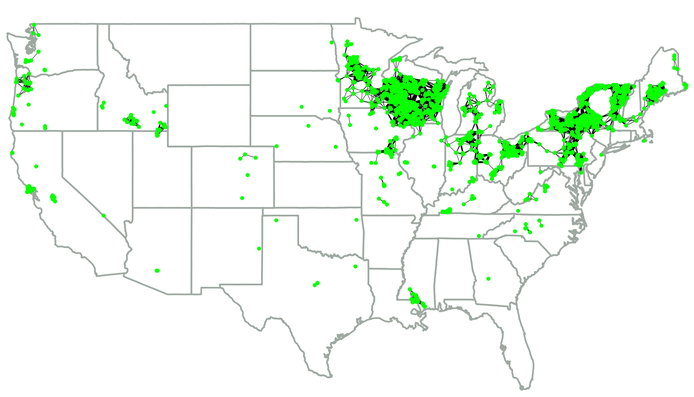
Simulated Organic Dairy Producer–Producer Network. 2002 – 2015
Figure 1. 2005



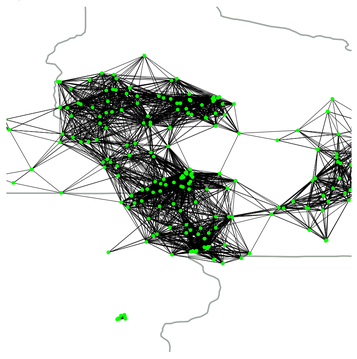
Simulated Organic Dairy Producer–Producer Network. 2002 – 2015
Figure 2. 2010



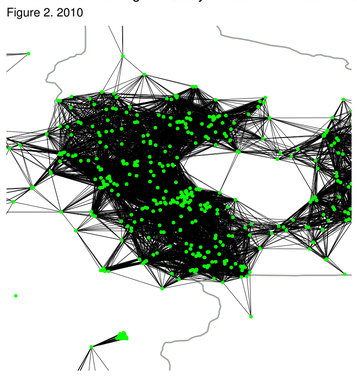
Simulated Organic Dairy Producer–Producer Network. 2002 – 2015
Figure 3. 2015



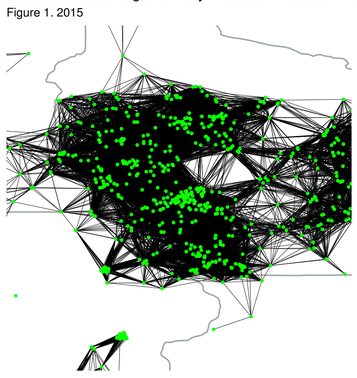
Detail Simulated Organic Dairy Producer–Producer Network. 2002 – 2015
Figure 1. 2005



Detail Simulated Organic Dairy Producer–Producer Network. 2002 – 2015
Figure 2. 2010

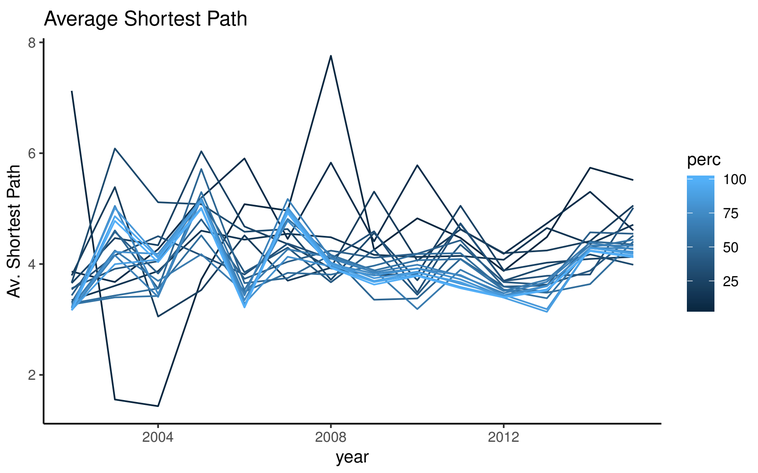


Detail Simulated Organic Dairy Producer–Producer Network. 2002 – 2015
Figure 1. 2015

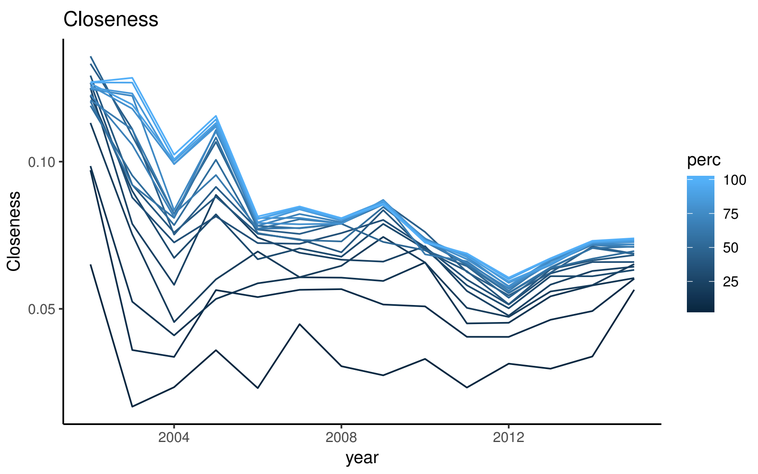


3.3 Simulated Network Results

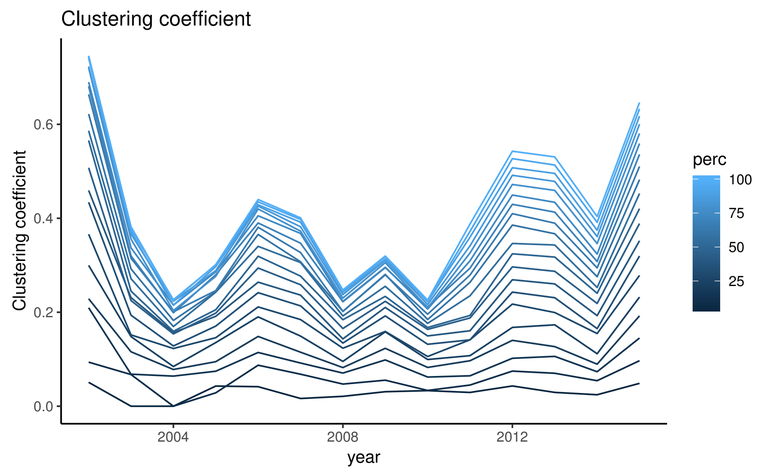
To maintain the relevance of closer connections we use the standardized inverse from 0 to 1 for the weight of the edges. A 50 mile distance is now almost 0 and 0 mile distance is now almost 1.



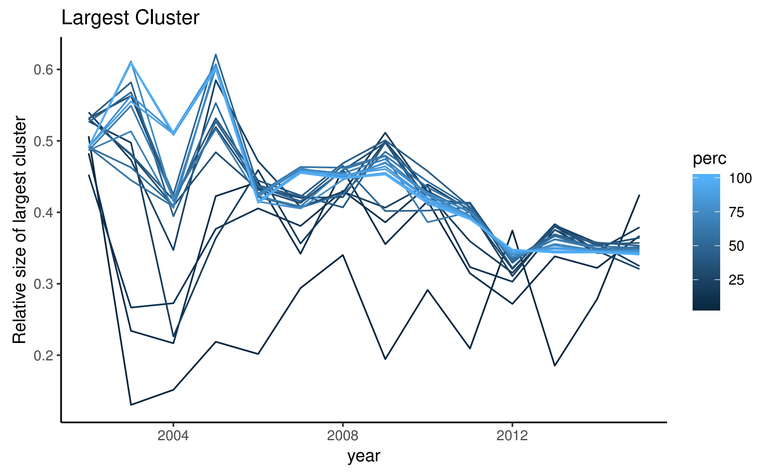
- The average shortest path is relatively stable over time. This is particularly clear for the cases of higher probabilities of being connected. This is a surprising result as most models for network evolution suggest that as the number of nodes grows, the average shortest path increases. This result may be due to the fact that our simulated networks are disconnected
- Over time, on average a farmer that wants to reach another farmer will need to go through 4 farmers



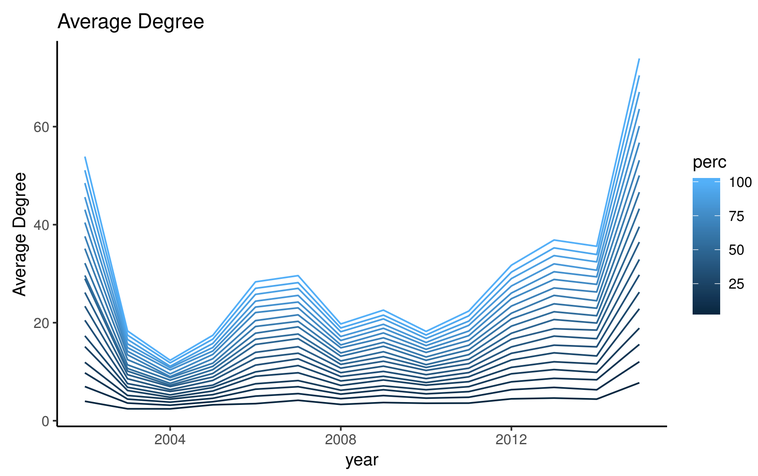
- For all levels of sociability, the average closeness decreases over time, which can be interpreted as an overall decrease in the number of shortest paths that go through each farmer
- Modified version of closeness, for disconnected graphs
- More cohesive network over time



- Before 2010 the clustering coefficient decreased, indicating that the closest neighbors became more tightly connected.
- After 2010 this doesn't hold true. The change in the clustering coefficient after 2010 may be due to the increase in new farmers over this period, which may have decreased the tightness of local communities.
- The change may have been a consequence of the sector's 2008 response to the recession.



- Relative size of the largest cluster remains relatively stable, this is a remarkable thing given the fact that the number of new entrants has increased over time.
- In spite of new entrants, the largest cluster remains quite large, covering almost 40% of the total number of farmers. This is particularly interesting as this network has been constructed with a 50-mile radius.
- Around 40% of the farmers in the country can be reached with hops that don't exceed 50 miles between each other.



- The number decreases in the first years and increases in the more recent years, especially after 2008.
- For the dairy farmers, this measure is interpreted as an increase in the average number of connections that organic dairy producers. The effect is stronger the greater the sociability assumed, as the top lines in the chart show steeper increases in the average degree increase, particularly after 2009.
- These findings support the idea that new entrants cluster around other established or new entrant organic dairy farmers.

4 Conclusion

The results evidence that the geo-location of new organic dairy producers may reflect advantages from proximity to peers such as potentially benefiting from knowledge spillovers, know-how transmission, minimizing risk arising from uncertainty, and minimizing discrimination towards organic production.

These effects may explain partially why the adoption of organic dairy production, which is more profitable has not been adopting in some regions of the country.

Further research can be needed to isolate the effect of networking in the adoption of organic dairy production as to isolate the effects of weather, land characteristics, and other economic effects such as income. Moreover, dairy handler facilities and distribution centers as well as supermarkets could be included to have a bigger picture.