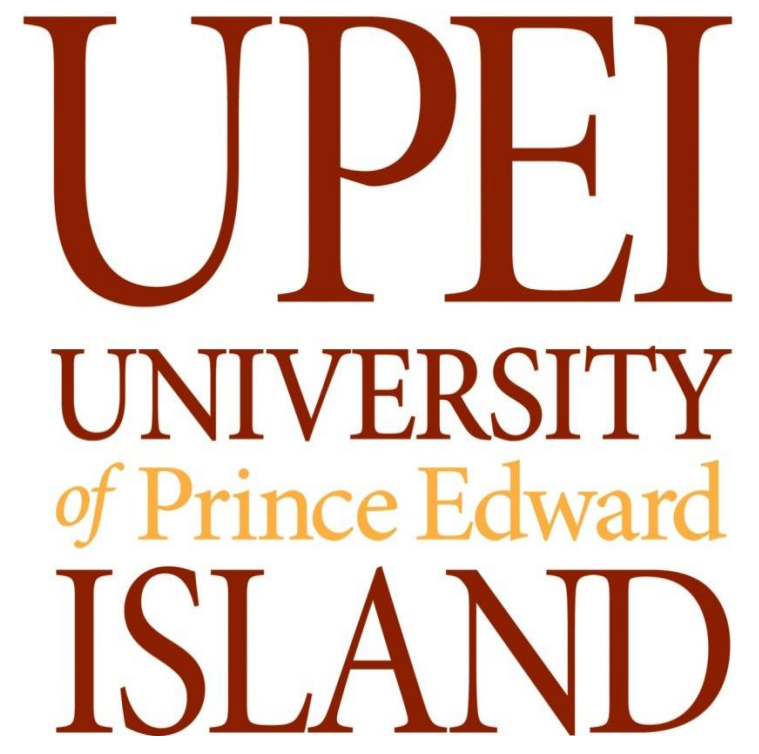# Analysis and characterization of swine movement in four Canadian provinces

Krishna Thakur, Daniel Hurnik, Crawford W. Revie, Javier Sanchez

Centre for Veterinary Epidemiological Research, Dept. of Health Management, UPEI, Canada

UPEI
UNIVERSITY
of Prince Edward
ISLAND

CVER
Centre for Veterinary Epidemiological Research

Background

❖ Direct and indirect contact via movement of infected animals and/or sharing of equipment, personnel, etc. among animal holdings are mechanisms for the spread of infectious agents.

❖ Analysis of contact patterns among animal holdings can aid in understanding the dynamics of infectious disease spread across the livestock industry as well as in targeted surveillance and the formulation of appropriate control strategies.

❖ Network Analysis (NA) based on graph theory provides a conceptual framework to study the pair-wise relationships between actors in a network. NA tools have recently been used in veterinary epidemiology to study patterns of animal movements and to explore the dynamics of infectious disease spread.

❖ Characteristics of the network can be used as important input parameters to simulate network based animal disease spread models and to estimate the potential epidemic size if an infectious agent were to occur in a network.

❖ No previous reports on network analysis research are available to represent the contact patterns among swine herds in Canada.

Materials and Methods

Swine Movement Data

❖ Data from a pilot pig traceability program from four Canadian regions recorded between July 1, 2004 and November 3, 2004 were used in this study.

❖ The information available included region of shipment, shipping and receiving farms, date of shipment, number of animals shipped, number of animals received and ID of truck involved in the shipment.

Network Analysis

❖ One-mode directed network of pig farms were created by week, month and for the whole study period where each farm was represented as a node and shipments between farms were connecting edges.

❖ In order to investigate the relationship among farms which shared trucks among movements, a two-mode network of pig farms and trucks was constructed.

❖ Parameters (degree, density, clustering coefficient, path length, diameter, components and infection chain) for these networks were extracted using social NA tools.

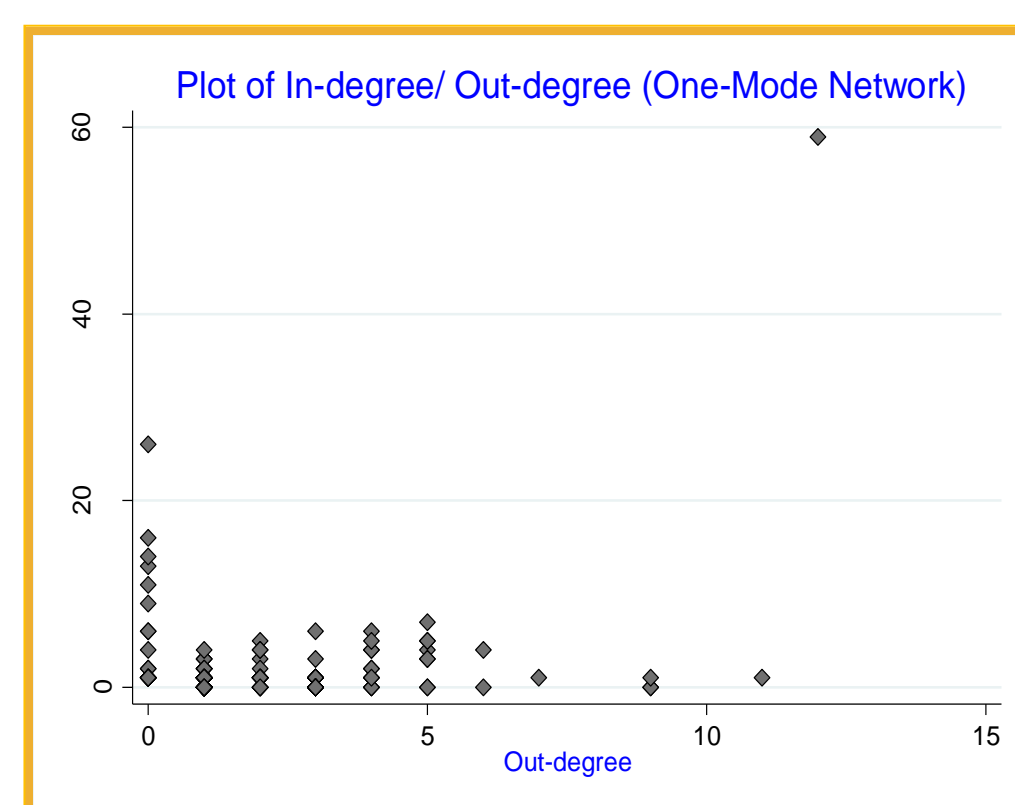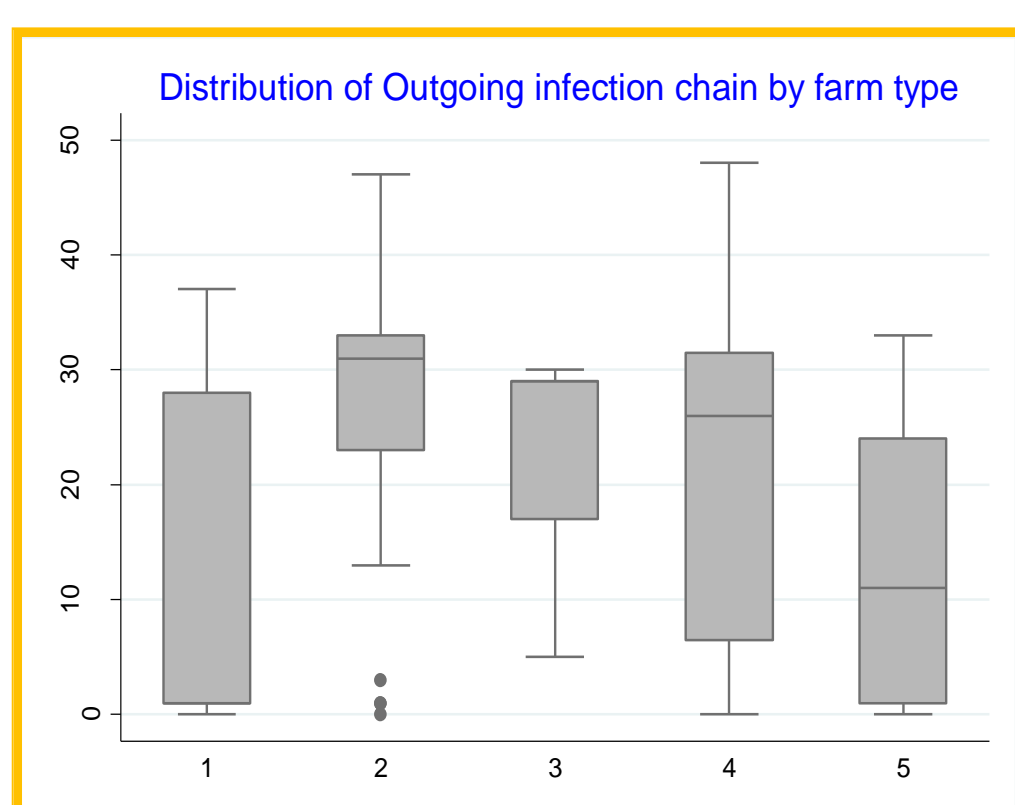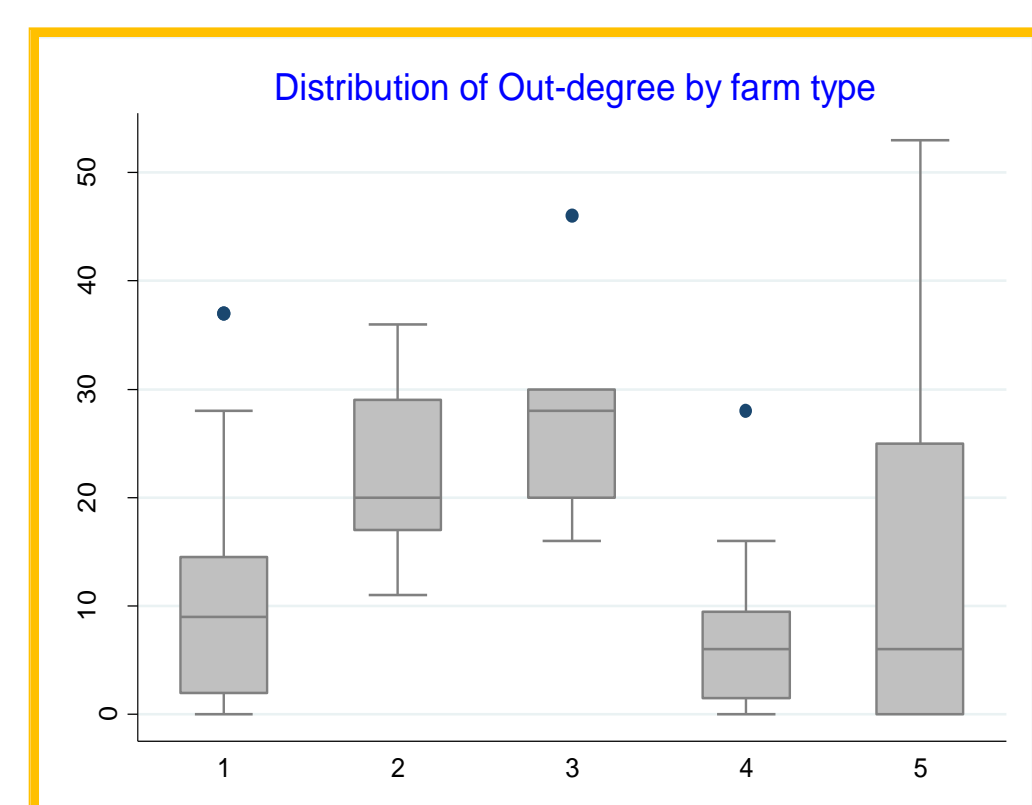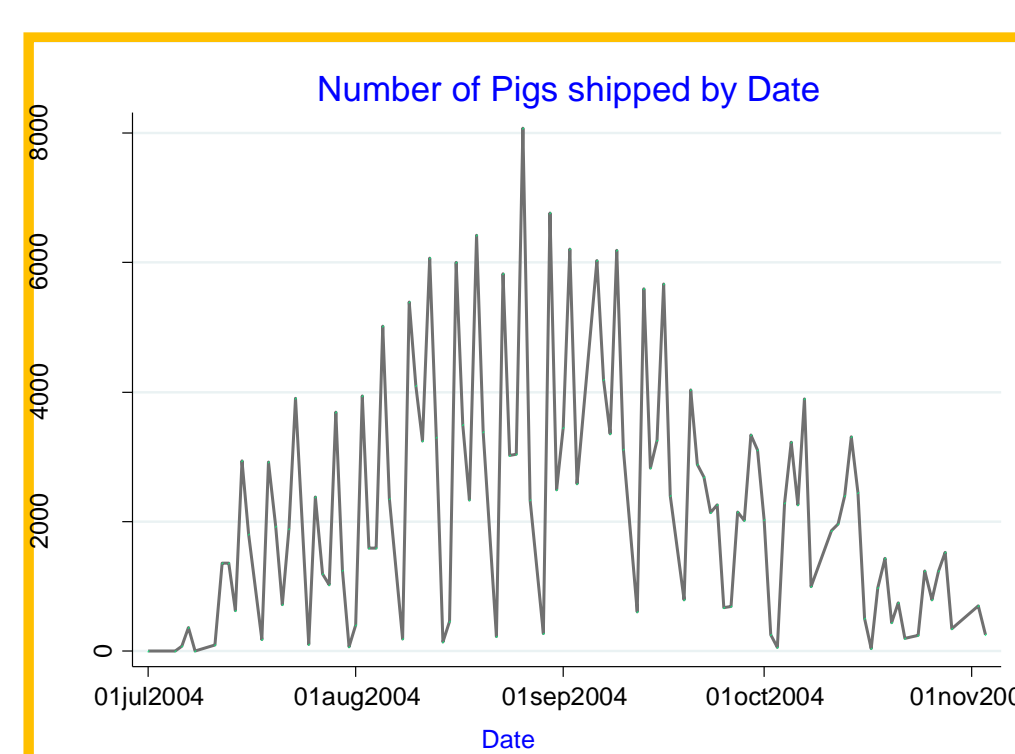❖ The NA was carried out using Ucinet 6.0, ORA, EpiContactTrace library in R and Stata 11.

Results

Pig Movement Summary

Number of Farms	158
Number of Trucks used	184
Number of shipments	2043
Mean Shipment Size (Range)	130.5 (1-700)
Mean shipments per farm (Range)	14.7 (1-48)
Mean distance moved in Km (Range)	988 (1-5966)
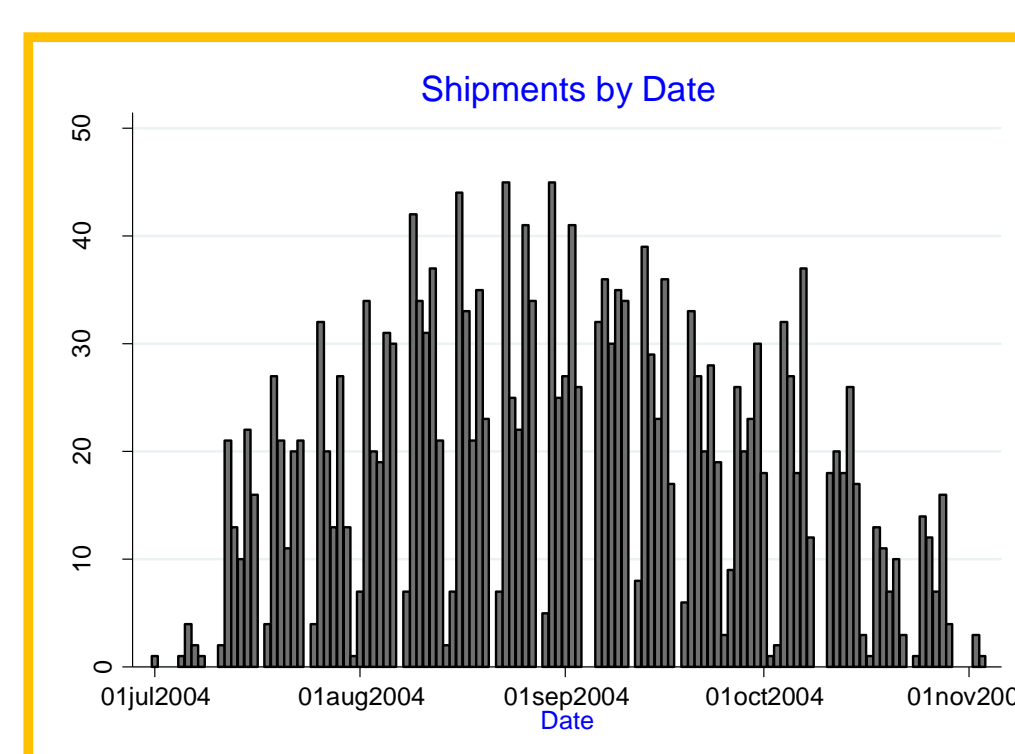
Farm type: 1 finishing, 2 farrowing, 3 farrow to finish, 4 nursery and 5 unclassified
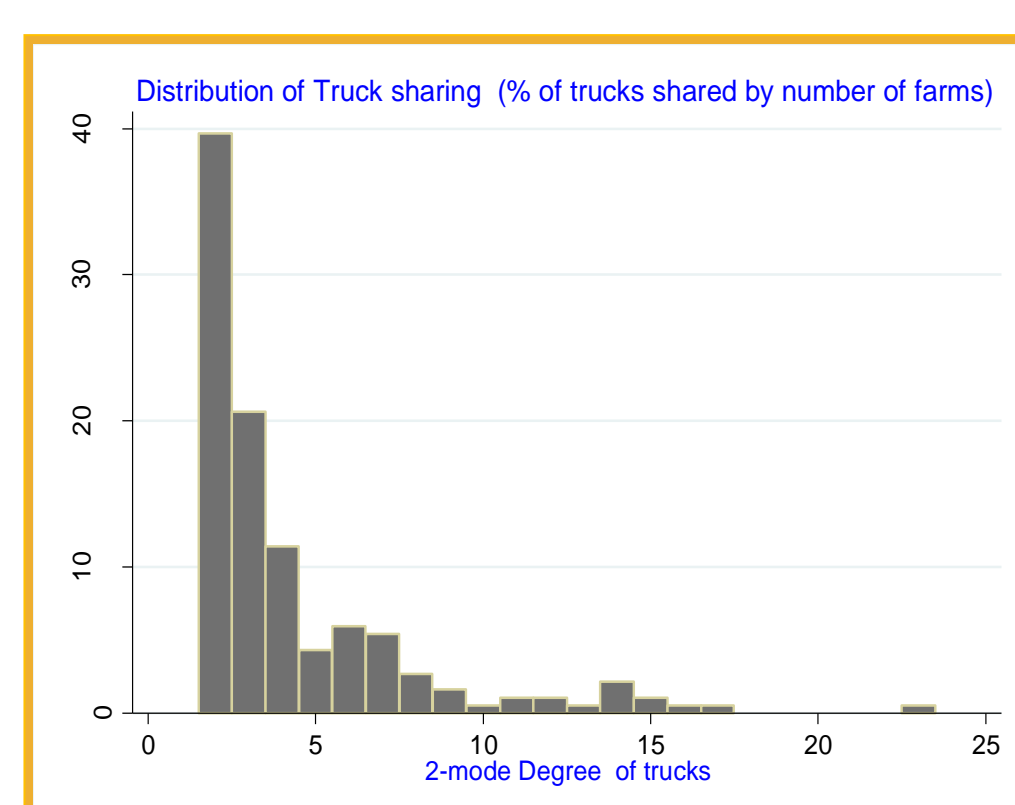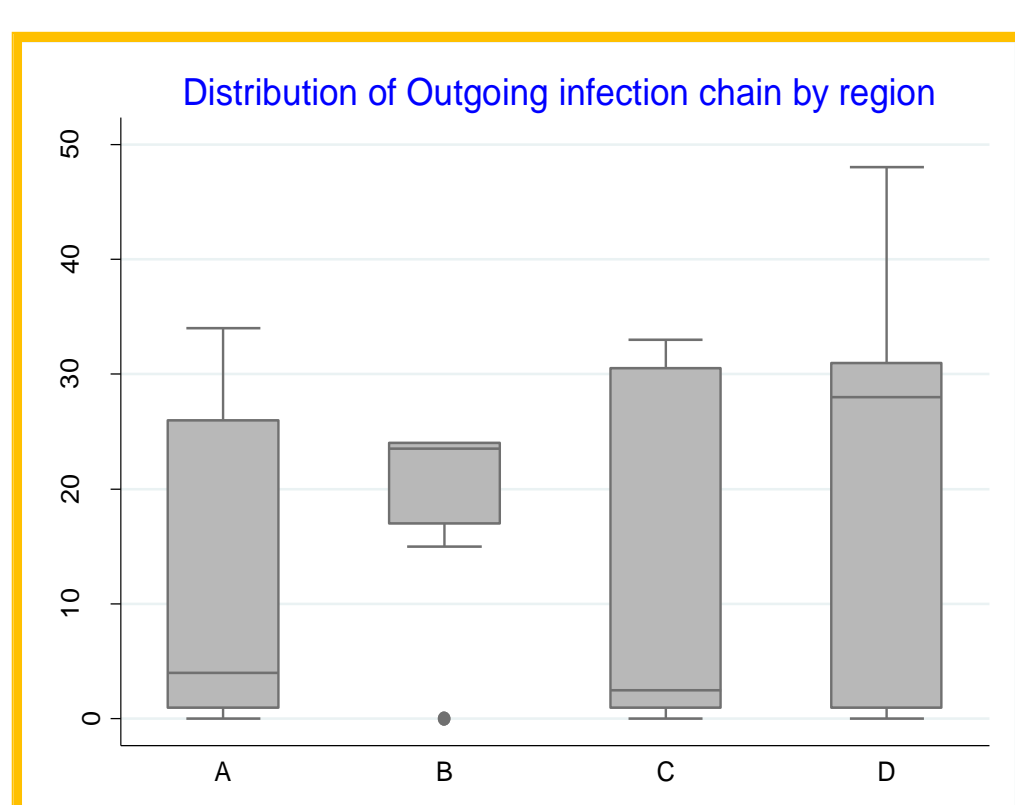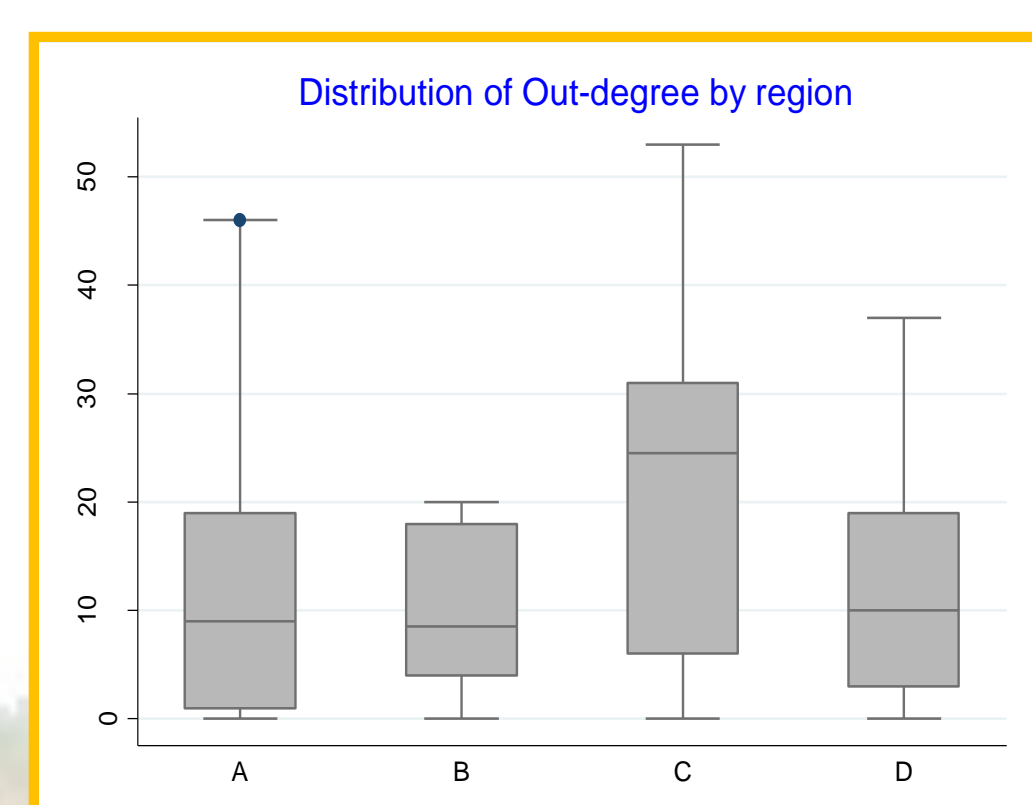
❖ Two-third of the trucks in the network were used for 2 or more shipments.

❖ Heterogenity in the distribution of ingoing and outgoing contacts (degree) in the network was noticed which fits a power law distribution; many farms had few contacts and a few farms had many contacts.

❖ Degree distribution of farms was significantly different among production types and regions (<0.05).

❖ Degree and Infection chain measures were not equivalent and not correlated. The two-mode network revealed that on average 5 farms (range 2-23) were indirectly connected via the sharing of a truck.

❖ Farms were on average 3 nodes apart in all the networks (Avg. Path Length).

## Network Characteristics

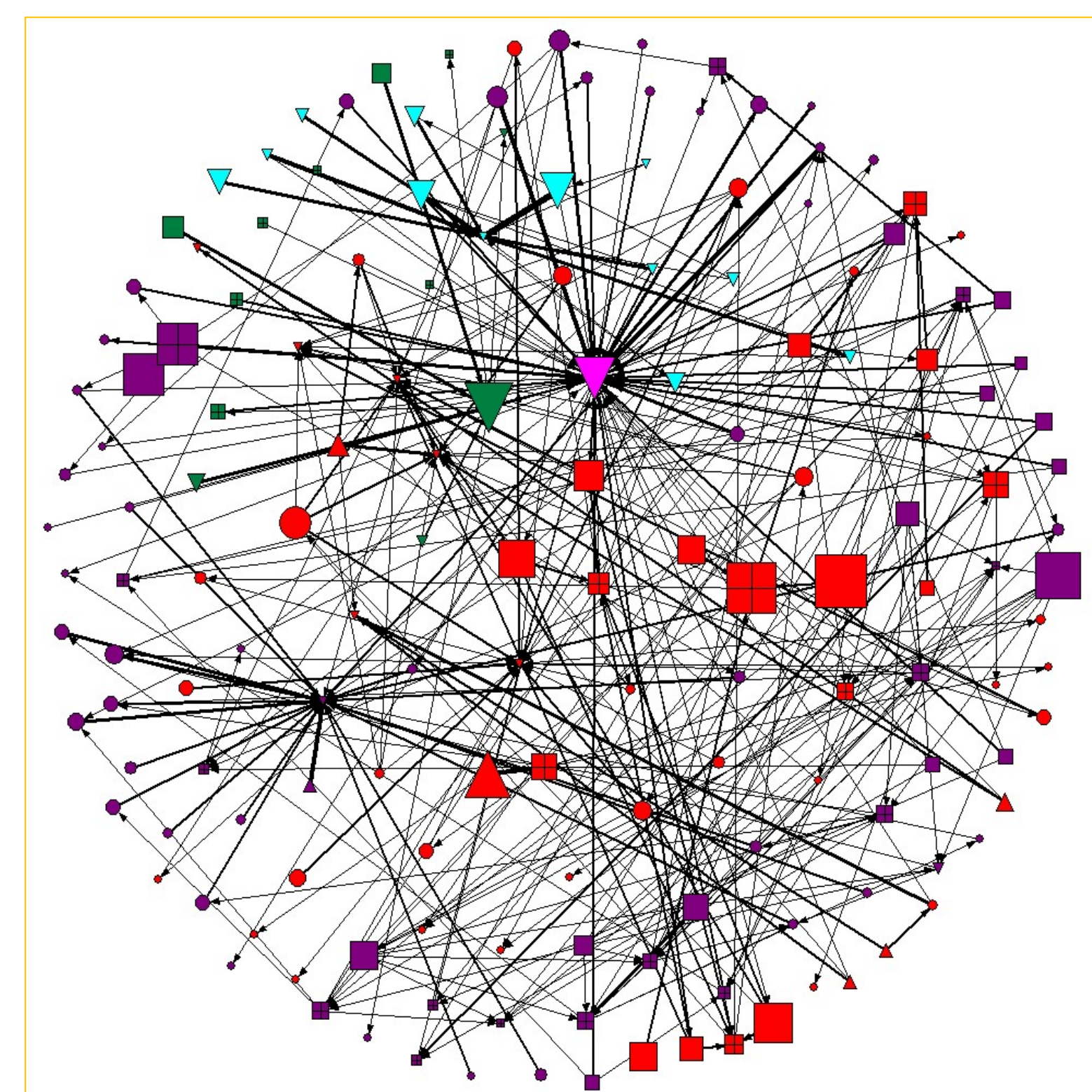| Network Measures	Overall Network	Monthly Networks Mean (Range)	Weekly Networks Mean (Range)
Size	158	158	67 (25-97)
Links	332	171 (104-294)	72 (9-113)
Average Degree	2.1	1.08 (0.66-1.87)	1.02 (0.8-1.13)
Density	0.013	0.007 (0.004-0.012)	0.021 (0.011-0.033)
Clustering Coefficient	0.09	0.05 (0.03-0.07)	0.01 (0-0.01)
Av. Path Length	2.92	2.88 (2.66-3.00)	2.55 (2.34-2.92)
Diameter	6	4 (3-6)	3 (2-6)
Reciprocity	0.0154	0.013 (0.009-0.017)	0.011(0.007-0.013)
Weak Component Number / Largest Size	1/158	54 (8-87)/ 98 (66-104)	5 (1-9)/ 48 (6-85)
Strong Component Number/ Largest Size	146/ 13	151 (150-157)/ 8 (2-12)	63 (22-87)/ 6 (2-9)
Infection Chain Mean/ Range	16/ 0-48	3.75/ 0-31	0.87/ 0-12

Figure 1. One-mode network map of pig movements in four Canadian regions (N=158). Node color indicates regions (Red: A, Aqua: B, Purple: C, Green: D and Pink: E), node weight is proportional to number of pigs shipped, node shape indicates farm type (circle: finishing, square: farrowing, up triangle: farrow to finish, box: nursery and down triangle: unclassified) and Edge weight is proportional to frequency of shipment between nodes.
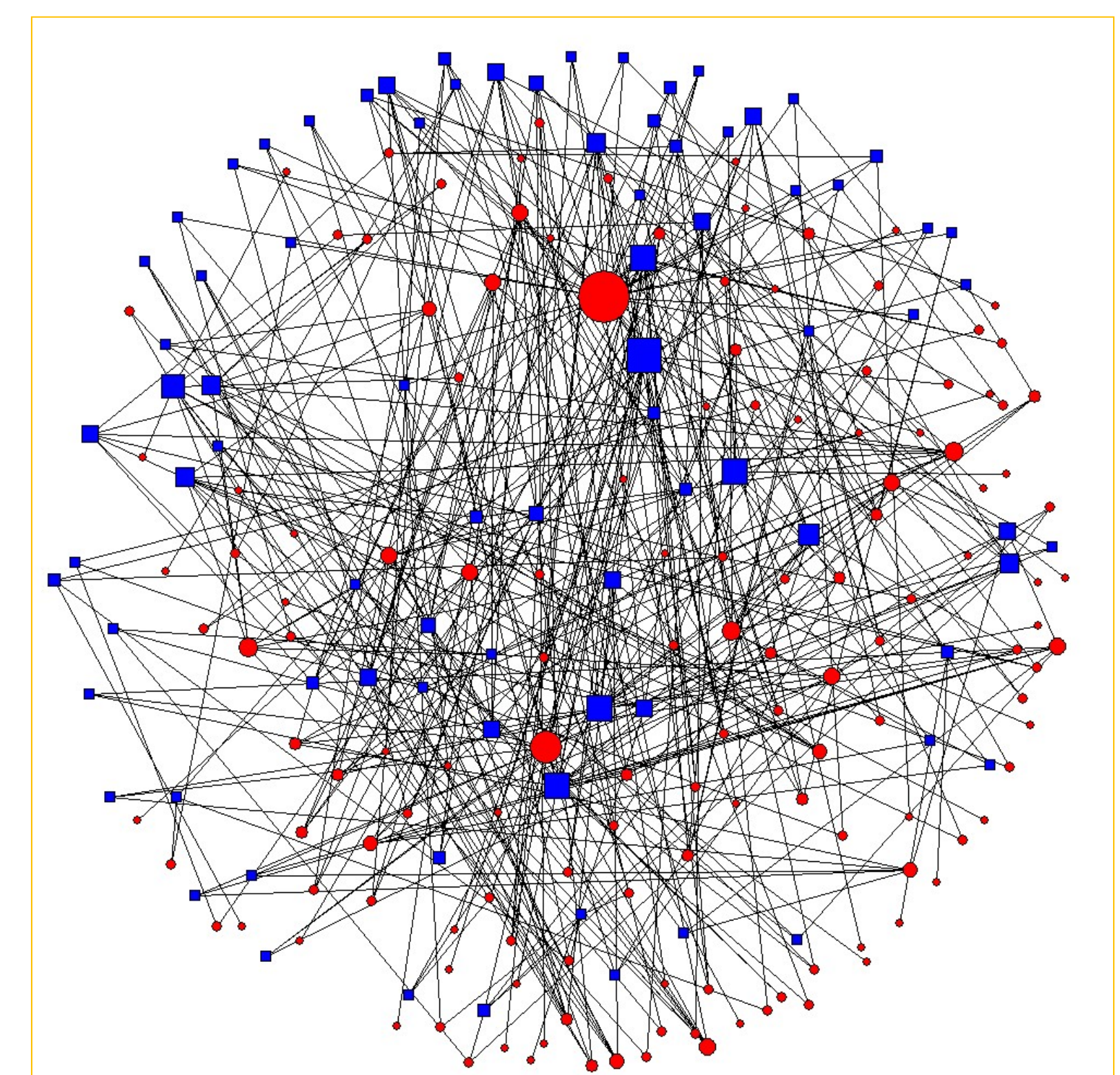

Figure 2. Two-mode network map of pig movements in four Canadian regions, N1 (Farms=140) and N2 (Trucks=82). Node shape and color indicates farms and trucks (blue squares: truck and red circles: farms) and weight is proportional to degree centrality of that entity.

Discussion

❖ Both the one- and two-mode networks suggest "small-world" and "scale-free" network topologies.

❖ Heterogenity in contact indicates the presence of "hubs" which are central in infectious agent spread and could be targeted for disease surveillance or to control the spread.

❖ The low reciprocities of one-mode networks indicate the hierarchical nature of pig industry.

❖ Trucks may have a role in spreading infection via indirect contact if trucks are not disinfected between successive shipments as for more than half of the shipments on any given day the same truck was used for 2 or more shipments.

❖ The outgoing infection chain may be a useful predictor of potential epidemic size as it considers the temporality of animal movements.

References : 1. Martínez-López, B et al., (2009), Social Network Analysis. Review of General Concepts and Use in Preventive Veterinary Medicine. Transboundary and Emerging Diseases, 56: 109–120
2. Dubé, C., et al., (2008), Comparing network analysis measures to determine potential epidemic size of highly contagious exotic diseases in fragmented monthly networks of dairy cattle movements in Ontario Canada. Transbound Emerg. Dis. 55, 382–392

Canadian Swine Health Board   Conseil canadien de la santé porcine

cver.upei.ca