CHAPTER 4

Results

4.1 Dataset Description Period November 2014 to October 2015

4.1.1 Poultry Movement

In total, 2,837 combined poultry movements were registered, including 44.73% (1,268/2,837) chicken, 12.84% (364/2,837) singing birds, 5% (140/2,837) DOC (day old chick), 0.3% (8/2,837) duck and 37.18 % (1,054/2,837) undefined poultry, this 2,837 movement was made by 10,033,941 poultry, in term of race, the majority contribution was 85.71% DOC (median: 13.480, range: 500 to 750.000, Kruskal–Wallis test, $p< 0.01$), 13.87% chicken (median: 1098, range: 1 to 100.000), 0.5% duck (median: 591, range: 2 to 1,500), 0.02% singing bird (median: 2, range 1 to 210) and 3% undefined poultry (median: 5, range 1-500,000) (Figure.4.1). The median distance of combined poultry movement was 1,118 km (range: 21 to 4,897 km), among this movement, the singing birds had longest movement with median 1,893 km (range: 185 to 3,191 km, Kruskal–Wallis test, $p< 0.01$), the nearest median distance were chicken 584 km (range: 27 to 4, 533 km) (Figure 4.2.).

The movement involved 26 Provinces on all five big islands (Java, Kalimantan, Sumatera, and Sulawesi). Central Java was the highest source 65% (1851/2837) of combined poultry movement events and destination 18 % (505/2837), West Java had 11% (321/2837) source and 8% (241/2837) destination of combined poultry movement, Lampung had more destination (4%, 120/2837) than origin combined poultry movement (0.9%, 28/2837). Jakarta was the second-high destination 13% (379/2837) combined poultry movement and only as area of destination, Central Java had 88 within province movement, West Java had 10 and Lampung had only 3. Considering district level, combined poultry movement involve 225 districts, number origin districts more (62%, 141/225) higher than (47%, 84/225) destination (Figure 4.3.).

4.1.2 Cattle Movement

Through November 2014 to October 2015, 1,372 cattle movements were recorded in the iSIKHNAS database. In these movements 11,654 cattle were involved. On average 8 cattle were moved per movement (median: 8, range: 1 to 67). The median distance of cattle was 190 km (range: 5 to 1,818 km) (Figure 4.1). Cattle movements included 16 provinces and mainly in Java and Sumatera Island. (Figure.4.3). The highest movement occurred (88%, 1,217/1,372) within Java island, 0.5% (5/1,372) within Sumatera Island, 4% (63/1,372) movement were from Sumatra to Java Island and 1% (13/1,372) movement from Java to Sumatera.

Majority movement concentrate in Central Java, this province had the highest source (84%, 1,157/1,372) and destination (46%, 636/1372) of cattle movement, almost half of movement were occured within this Province (52%, 606/1,157), West Java had the third of source (5.6%, 77/1,372) and second high destination (28%, 393/1,372) movement, ten percent (40/393) were within movement in this Province, the source of movement cattle in Lampung were higher than as a destination. In contrast with poultry movement, the number of origin district (23%, 35/143) were lower than destination (77%, 110/143) (Figure 4.3.).

A. Distance of movement

B. Quantity of species

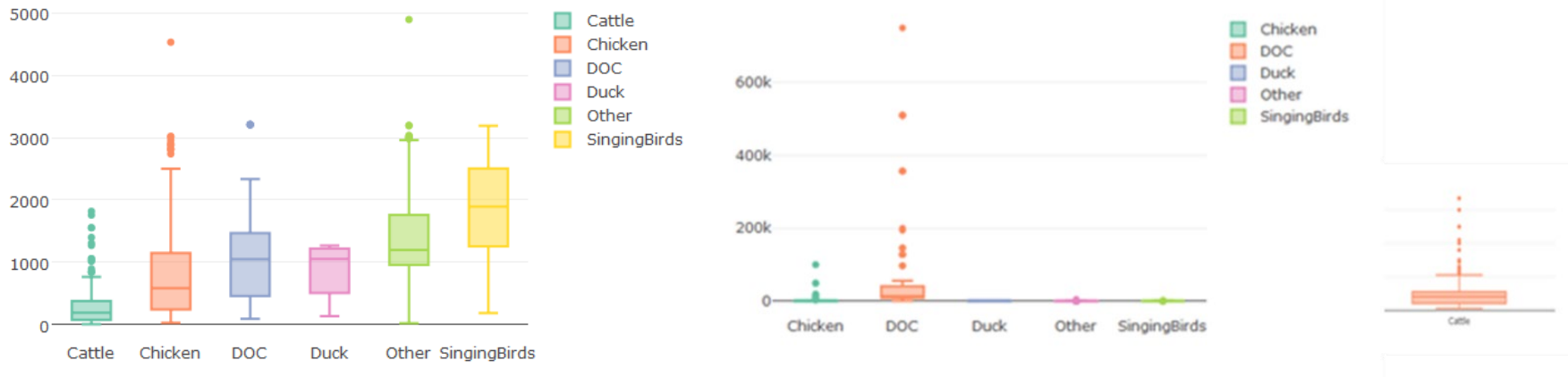


Figure 4.1 The distribution of distance (A) and quantity of poultry and cattle (B) moved between November 2014 and October 2015 in Lampung, West Java and Central Java Province

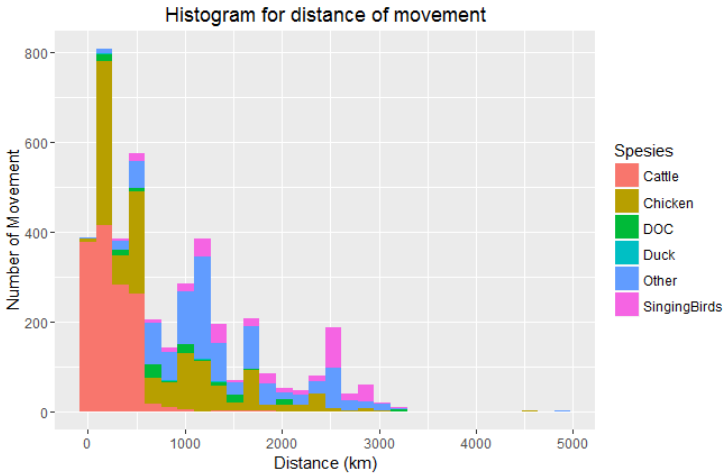


Figure 4.2 The histogram of distance poultry and cattle movements between November 2014 and October 2015 in Lampung, West and Central Java Province.

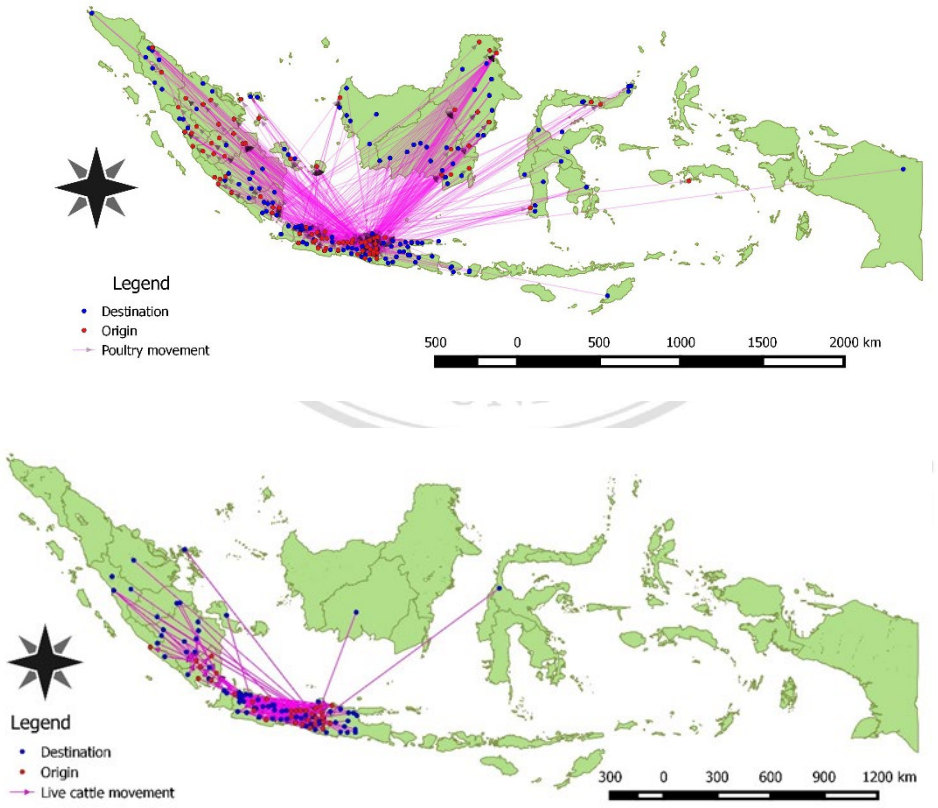


Figure 4.3 The geographical map showing live poultry (above) and cattle (below) movements from and into Lampung, West Java and Central Java Province. Each line indicates directed movements from one district to another district.

4.2 Social Network Analysis

4.2.1 Centrality Parameter of Combined Poultry Network

The score of mean in-degree and out-degree are same, because the reason for this is that a movement between two districts will contribute equally to the in-degree of one district and to the out-degree of another holding, and because all district in the network are included when calculating the means, they will be the same, this also applies for ingoing and outgoing contact, the mean in-degree and out-degree of combined poultry network were 2.6 (95% CI: 2.3-2.9) (Figure 4.4), Chicken had higher in-degree and out-degree compare to DOCs and ducks. Singing birds also had more significant higher mean in-degree and out-degree than duck ($p< 0.01$). Betweenness of combined poultry network had mean 150 (95% CI: 85-215), In terms of poultry type, there were no significant in the mean of betweenness (Figure 4.4.).

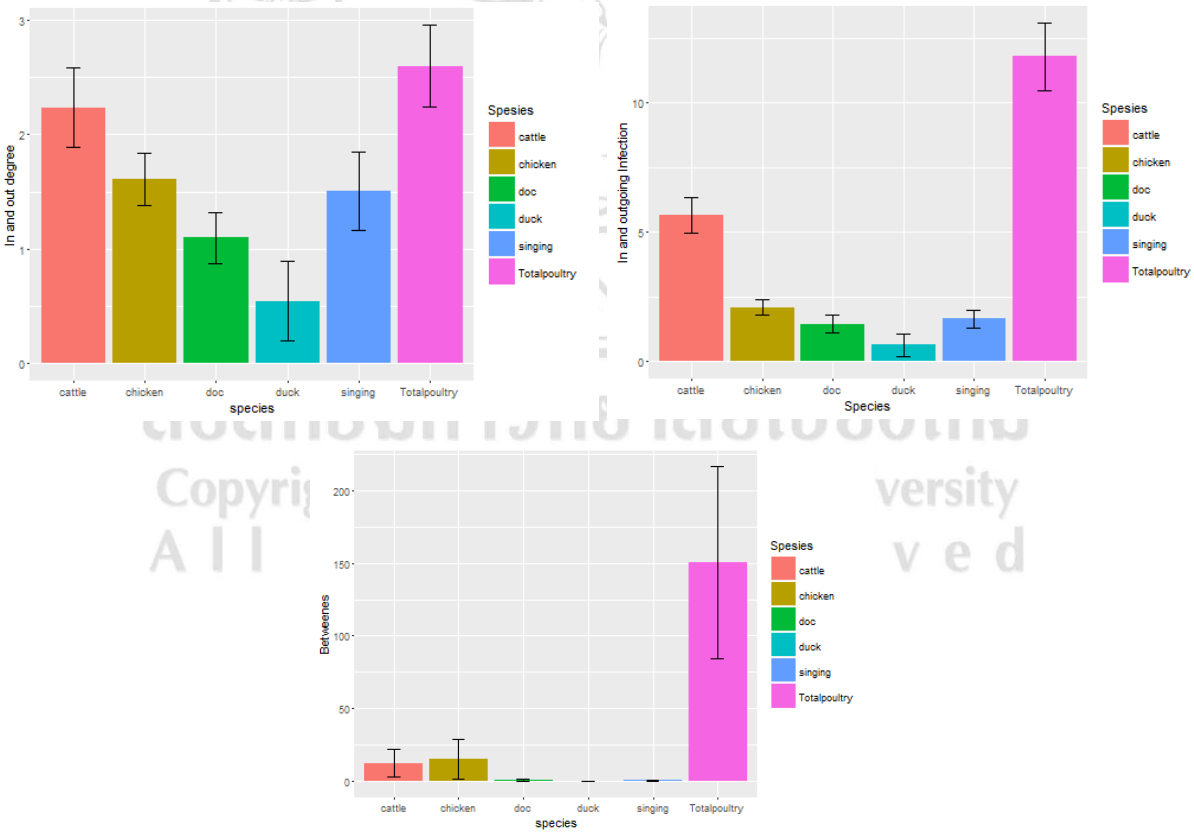


Figure 4.4 The mean in-degree, out-degree, ingoing contact chain and outgoing contact chain and betweenness combine poultry and cattle network.

In a combined poultry network, the number of districts delivering poultry to other districts (in-degree) ranged 0 to 15 (median 1), the range out-degree was wider (median=0, range 0-54), all types of poultry had the same of median (1) in-degree, similar with out-degree, outgoing contact chain (median= 0, range 0-176) had a wider range than ingoing contact chain. Chicken network had the widest range of betweenness compare to other type of poultry.

Table 4.1 Median and range in-degree, out-degree, ingoing contact chain and outgoing contact chain between November 2014 and October 2015 in Lampung, Central and West Java Province.

Network	In-degree	Ingoing contact chain	Out-degree	Outgoing contact chain	Betweenness
Combined poultry	2 (0-15)	10 (0-41)	0(0-54)	0(0-176)	0 (0-3,751)
Chicken	1(0-8)	2 (0-11)	0(0-41)	0(0-58)	0 (0-826)
DOC	1(0-4)	1 (0-5)	1(0-15)	0(0-15)	0 (0-14)
Singing birds	1(0-9)	0 (1-9)	0(0-32)	0(0-35)	0(0-17.5)
Duck	1(0-1)	0 (1-2)	1(0-1)	1(0-2)	0(0-1)
Cattle	1(0-10)	7(0-14)	0(0-57)	0(0-86)	0(0-425)

In the combined poultry network, Boyolali had the highest out-degree, the third highest betweenness and a low in-degree. Banjarmasin had the highest in-degree and betweenness, however the out-degree was low. There were two districts with high centrality measures in the chicken network, Rembang with a high out-degree and Semarang with a high out-degree and betweenness. These two districts are located in Central Java Province. The highest centrality measure in the DOC network belonged to Purwakarta which had an out-degree and betweenness score and Medan which had the highest in-degree. The singing bird network had the highest out-degree in Tarakan and

Boyolali which had a high betweenness and out-degree. The district with the highest centrality measure in duck network was Semarang (Table 4.2).

Table 4.2 The highest centrality measure: in-degree, out-degree and betweenness between November 2014 and October 2015 in Lampung, Central and West Java Province.

Network	Province	Districts	In-degree	Out-degree	Betweenness
Combined poultry	Central Java	Boyolali	4	54	3,011
	South Kalimantan	Banjarmasin	15	7	3,750
Chicken	Central Java	Rembang	0	41	0
	Central Java	Semarang	8	38	826
DOC	Central Java	Purwakarta	1	14	15
	South Sumatera	Medan	4	0	0
Singing bird	North Kalimantan	Tarakan	0	32	0
	Central Java	Boyolali	3	6	17.5
	Central Java	Surakarta	9	0	0
Duck	Central Java	Semarang	1	1	1
Cattle	Central Java	Boyolali	1	57	308
	Central Java	Semarang	6	22	425
	DKI Jakarta	East Jakarta	10	0	0

The scatter plot in-degree against ingoing contact chain, and out-degree against outgoing contact chain were not always consistent, there were districts with low degree had high contact chain. The correlation betweenness in-degree and out-degree was very low (correlation coefficient: 0.22, $p<0.05$), indicate only very few districts as a supplier are the same one as the destination of poultry (Figure 4.5.).

A Moran's I statistic demonstrated out-degree and betweenness in West and Central Java was weak positive (out-degree I: 0.10, betweenness I: 0.13) of spatial autocorrelation and significant (out-degree $p=0.05$, betweenness $p=0.05$) at spatial lag of one or first neighborhood district. However, score of in-degree had non-significant, ($p=0.16$) and negative spatial autocorrelation (I: -0.11). In contrast, Lampung Province

had no significant negative spatial autocorrelation for out-degree (I: -0.14, p=0.4) and betweenness (I: -0.13, p=0.4), the in-degree had significant and weak positive autocorrelation (I: 0.03, p=0.05) at spatial lag one.

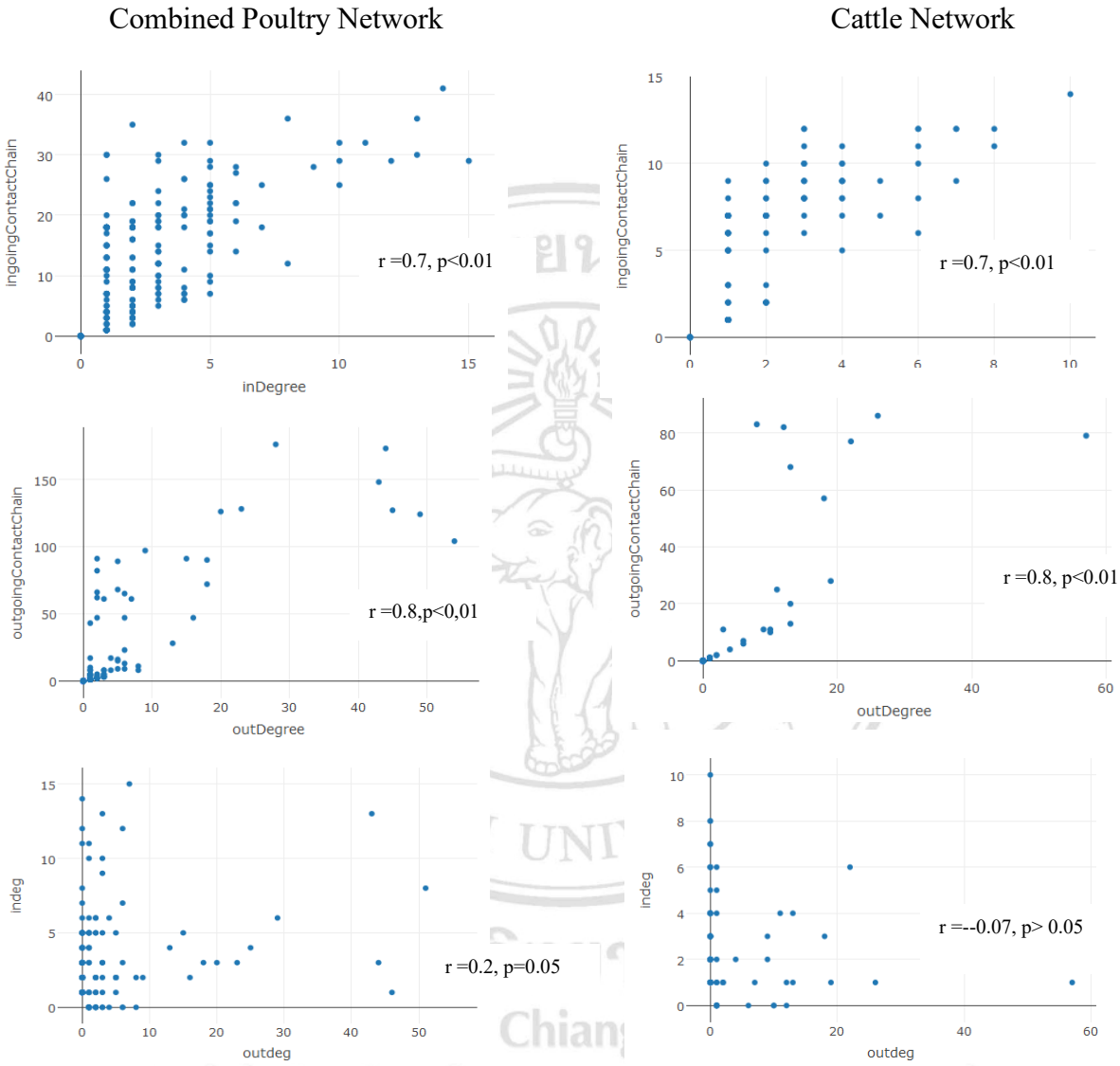


Figure 4.5 Scatter plots of ingoing contact chain and in-degree, outgoing contact chain and out-degree, in-degree and out-degree. Poultry (left) and cattle (right) network.

4.2.2 Centrality Parameter of Cattle Network

The mean degree was 2.4 (95% CI: 2-2.8), lower than in and outgoing (5.6, 95% CI: 5-6.2), betweenness of cattle network were 12.4 (95% CI: 22-2.8). The out-degree (0-57) had a wider range than in-degree (0-10), similar with out-going (0-176) more wider compare to ongoing contact (0-41). Choropleth map show majority Districts with a high out-degree and betweenness in the study area were Boyolali and Semarang, while districts with a high in-degree were located in the capital city (Jakarta).

There was no correlation between in-degree in out-degree ($p=0.3$, $r=-0.07$), however mean of in-degree and ingoing contact chain ($p<0.01$, $r=0.7$) and out-degree and outgoing contact chain ($p<0.01$, $r=0.8$) have positive correlation.

Correlogram of cattle network in West Java and Central Java showed nearly neighboring (spatial lag two) districts had similar in-degree ($p=0.005$, I: 0.2), however out-degree ($p=0.08$, I: 0.1) and betweenness ($p=0.1$, $I=0.08$) had no significant spatial autocorrelation, while, in Lampung Province, in-degree ($p=0.4$, I: I -0.07) and out-degree ($p=0.3$, I: -0.01) and betweenness had no spatial autocorrelation were found.

4.2.3 Monthly Centrality Parameter of Combined Poultry Network

The monthly mean in-degree and out-degree are shown in Figure 4.6. In the combined poultry network the mean in- and out-degree start increasing from April to July (1.5 to 2-fold increase) when Idul Fitri, it marks the end of Ramadan festival breaking the fast, occurs in the middle of July. It then drops in August, and afterwards increases again from September to October (1.4-fold increase) when the second biggest annual festival Adha occurs, many Muslims families or groups of families may purchase a livestock (cattle, goat or sheep) known as *udhiya*, to sacrifice during Idul Adha.

4.2.4 Monthly Centrality Parameter of Cattle Network

The mean in-degree and out-degree start increasing in July, two months prior to the Idul Adha festival. During this festival in September, the mean of (in and out) degree increases 3-fold. Apart from these two months the mean in-degree and out-degree was never above 0.4.

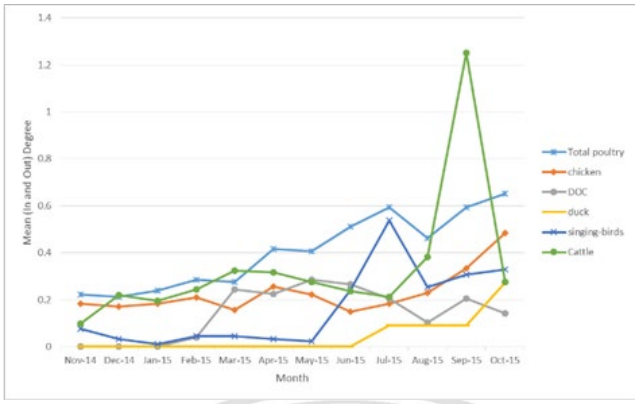


Figure 4.6 Means of in-degree and out-degree for monthly, combine poultry and cattle network.

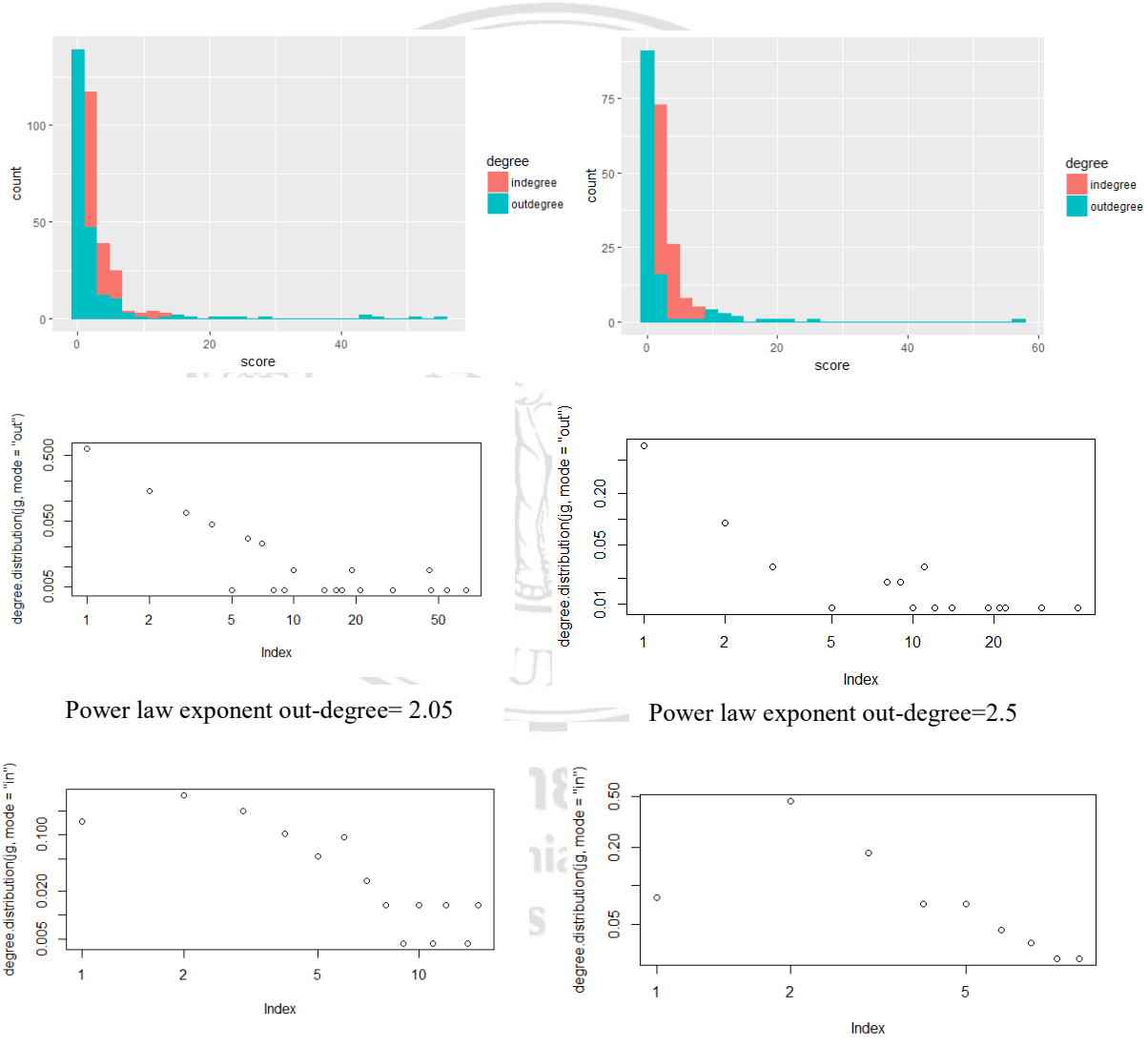
4.2.5 Topology of Combined Poultry Network

The combined poultry network comprised of 225 nodes. If divided by poultry type, the chicken network had the highest number of nodes (154) followed by singing bird (91), DOC (50) and duck (11) network. The out-degree centralization for combined poultry network (0.23) was greater than in-degree centralization (0.05), similar result also was found in chicken, DOC and singing bird network. Of the total number possible link in the combined poultry network (50,400), only 1% (575/50,400) were actually present, reflected a low density, the density take value between 0 to 1, 0 are extreme value that indicate no contacted (absence of network) and 1 showed all possible contact that could occur in the network. This lower density also found when combined poultry network divided into type of poultry, including chicken (1%, 247/ 23,562) and singing bird (1%, 91/8,190), DOC (2 %, 55/2750) and duck (9 %, 6/66) network.

Out-degree centralization for the combined poultry network was greater than the in-degree centralization (0.23 versus 0.05), the same results were also found in the chicken (0.25 versus 0.04) and singing birds (0.3 versus 0.08). Only duck network showed a similar score between out-degree and in-degree centralization (0.05).

The cluster coefficient for network combined of poultry (0.1) was larger compare with (0.01) random networks with the same number of node and link. The average geodesic distance for network combined of poultry (3) was slightly similar with

random network (3.5), we conclude the combined of poultry network has small world network properties, however after the network stratified by type of poultry, cluster coefficient for chicken network was similar with random network (0.01) and the singing birds network (0.03) was smaller compare to random network (0.06) and DOC networks no cluster was found, average geodesic distance were smaller for all type of poultry, therefore chicken, singing birds and DOC networks showed no evidence of small network properties.



Power law exponent out-degree= 2.05

Power law exponent out-degree=2.5

Power law exponent in-degree= 3.7

Power law exponent in-degree= 2

Figure 4.7. Degree distribution Log-log plot and of poultry (left) and cattle (right) network.

The log-log scale of out-degree combined poultry network approximated with power law distribution, with exponent 2.5, however exponent in-degree combined poultry network is 3.7, higher value from power law distribution, which lie in the range 2 to 3 (Clauset et al., 2009) (Figure. 4.7), the longest shortest path between any two districts (diameter) in combined poultry network was 10, singing birds had the furthest diameter (8), followed by chicken (7), DOC (6) and ducks (2).

The combined poultry network has one largest strong component of 42 districts and 183 component composed single district, all the districts belong to one single weak component. This network contains 19 cut points, whose deletion increases the number of components in the network, chicken networks consist one largest strong component of 6 districts, three weak component, and each component contain 2 districts. DOC network has one strong component of 2 districts and one largest weak component of 9 districts, singing birds network has one strong component of 2 districts, two weak component, each component contain 2 districts, cut points were not found in all type of poultry.

Table 4.3 Descriptive of poultry and cattle network during November 2014 to October 2015

Measurement	**Type of Network**					
	Poultry	**Chicken**	**Singing birds**	**DOC**	**Duck**	**Cattle**
Node	225	154	91	50	11	124
Number of links	575	247	129	55	6	277
Density	0.01	0.01	0.01	0.02	0.09	0.02
Clustering coefficient	0.1	0.01	0.03	0	0	0.08
Clustering coefficient random network	0.01	0.01	0.06	0.03	0.8	0.027
Average geodesic distance	3	3	3.4	3	1.09	3
Average geodesic distance random network	3.5	4.3	4	4.5	1.2	3.3
In-degree centralisation	0.05	0.04	0.08	0.06	0.05	0.06
Out-degree centralisation	0.23	0.25	0.3	0.2	0.05	0.4

4.2.6 Topology of Cattle Network

The network created from cattle movement contains 124 nodes and 277 direct links. The ratio number of links in the network over the total number of possible links was 2 %. This network was also characterized with an out-degree centralization greater than an in-degree centralization (0.4 versus 0.06).

The average geodesic distance for cattle network and random network of similar size was 3 and 3.3, respectively. The clustering coefficient for cattle network (0.08) was greater for the random network (0.027), consistent with a network with small network properties. In-degree and out-degree distribution of cattle network appeared linear on log-log scale with respectively power law exponent 2 and 2.5, respectively. The longest-shortest path between any two districts (diameter) was 8.

The cattle network has one large strong component which contains 10 districts (Boyolali, Grobogan, Indramayu, Kendal, Klaten, Purbalingga, Rembang, Semarang and Tasikmalaya) and 114 strong component composed single districts, one single weak component containing all the node and there were 5 cut points in this network.

4.2.7 Topology of Monthly Combined Poultry Network

The median nodes of monthly combined poultry network were 77. The number of nodes increased in September (106) and October (108). In the month of May, the cluster coefficient for observed network was 5 times higher than the random network, whereas the average geodesic distance was 4 in the observed network and 4.5 in the random network. These results are consistent with small world properties. There were no small world characteristics detected in any other month.

The median nodes of monthly combined poultry network were 77, the number of nodes was increased in September (106) and October (108), the average geodesic distance also higher in October (5.7), however the cluster coefficient were higher in May and July (0.02), in the month of May the cluster coefficient for observed network 5 times more higher than random network, whereas the average geodesic distance were 4 and 4.5 in random network, this result were consistent with small world properties. Additionally,

there were no small world characteristics detected in another month. The density of the monthly poultry network was relatively stable with median 0.01. The chicken showed a similar pattern with the combine of combined poultry, the number of nodes were high in September (58) and October (72).

The monthly component of network combined poultry shows strong component was never up to than 3 (2.8%) districts, the median monthly weak components were 76 (range 41 to 98), the largest weak and strong component occurred in September (strong component of size 3 (2.8%) districts, weak component of size 98 (92%) district and October (weak component of size 3 (2.8%) district, strong component of size 95 (88%) district) cut points were not found in monthly of poultry network.

4.2.8 Topology of Monthly Cattle Network

The median number of nodes was 33 and increased in September (81). This month also showed small world properties with a cluster coefficient 2 times higher than for a random network and average geodesic distance for observed and random network of similar size was 4.7 and 3.3, respectively.

The monthly component of cattle network had two (Boyolali and Semarang districts) cut points, bridging is calculating the subsequent changes in network cohesion (measured as the inverse average geodesic distance) (Valente and Fujimoto, 2011), in this network the highest average geodesic distance was 4.7 in month of September with median 2.8, the largest strong component of size 4 (5%) districts in and the largest weak component of size 73 (90%) in September.