Feeder Space Study

Analysis

Introduction:

In this study, we are willing to help the egg producer improve the production effectiveness in cost. The producer owns a hen house. There are 96 cages in the house which are numbered with unique ID, and each cage contains 15 hens. The cages are placed in a typical order in the hen house. Starting from the door and along the walkway, there are 48 cages on each side. The cages on both sides were further divided into 4 tiers, each tier has 12 cages. Also, the numbers 1 to 12 represent the distance from the door.

Our treatment factor is the feeder space. 6 different feeder space are randomly assigned to each tier, so it repeats 2 times in each tier, 8 times on each side, and in total the data collected for the same feeder space is repeated 16 times for most of the feeder space (some feeder space has missing values in their data). By multiplying the levels of feeder space (6) and the number of times repeated (16), we confirm it is equal to the number of all cages which is 96.

To predict the production of eggs, we have the treatment factor, which is the feeder size (6 levels). The other factors are tiers (8 levels), and the distance to the gate (number 1 to 12). We also have predictors of the hen's consumption of food, and their age in weeks when the data is collected. These predictors are continuous.

Model:

$$Production \sim Consumption + Age + Treatment + Dist + Tier + Dist \times Tier$$

Degrees of Freedom:

Predictor:	Degrees of Freedom:
Consumption (continuous)	1
Age (continuous)	1
Feeder Space (treatment, 6 levels)	5
Distance (continuous, 1 to 12)	1
Tier (8 levels)	7
Distance*Tier (8 levels)	7
Error	1086

We create blocks with the distance to the door and the tiers. Adding up the df of distance (1), tier (7), and their interactions (1*7), we get 15 which is the number of blocks (16) minus 1. Since the production of eggs is not likely to be affected by the cage on which side of the walkway, we treat “Side” as a random factor. The number of distance represents the real distance from the door which is not just a number to differentiate the levels. Thus, we treat distance as continuous. The 6 level of feeder space is contained in each block. We consider this to be a Randomized Complete Block Design.

Model Summary:

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Analysis of Variance Table

Response: ProductionPerHen_eggDay
                          Df Sum Sq Mean Sq  F value    Pr(>F)
ConsumptionPerHen_gDay     1 0.9320 0.93200 123.0478 < 2.2e-16 ***
WeeksOfAge                 1 1.0556 1.05561 139.3675 < 2.2e-16 ***
Treatment_feeder_inch      5 0.2773 0.05546   7.3215 9.266e-07 ***
DistanceFromDoor           1 0.0776 0.07759  10.2435  0.001411 **
Tier_8                     7 0.0703 0.01005   1.3264  0.234060
DistanceFromDoor:Tier_8    7 0.1309 0.01870   2.4695  0.016212 *
Residuals               1086 8.2257 0.00757

Residual standard error: 0.08703 on 1086 degrees of freedom
Multiple R-squared:  0.2362, Adjusted R-squared:  0.2207
F-statistic: 15.27 on 22 and 1086 DF,  p-value: < 2.2e-16
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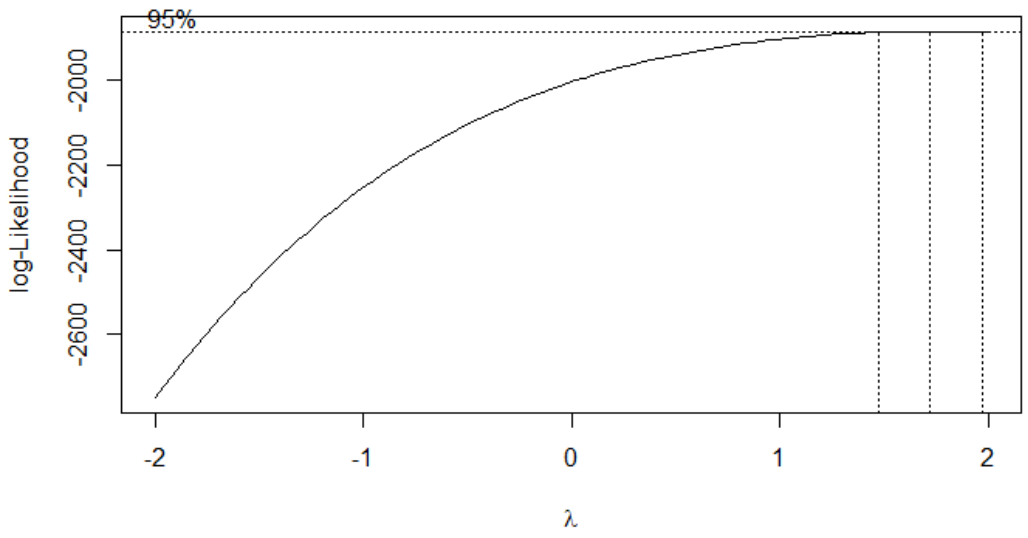
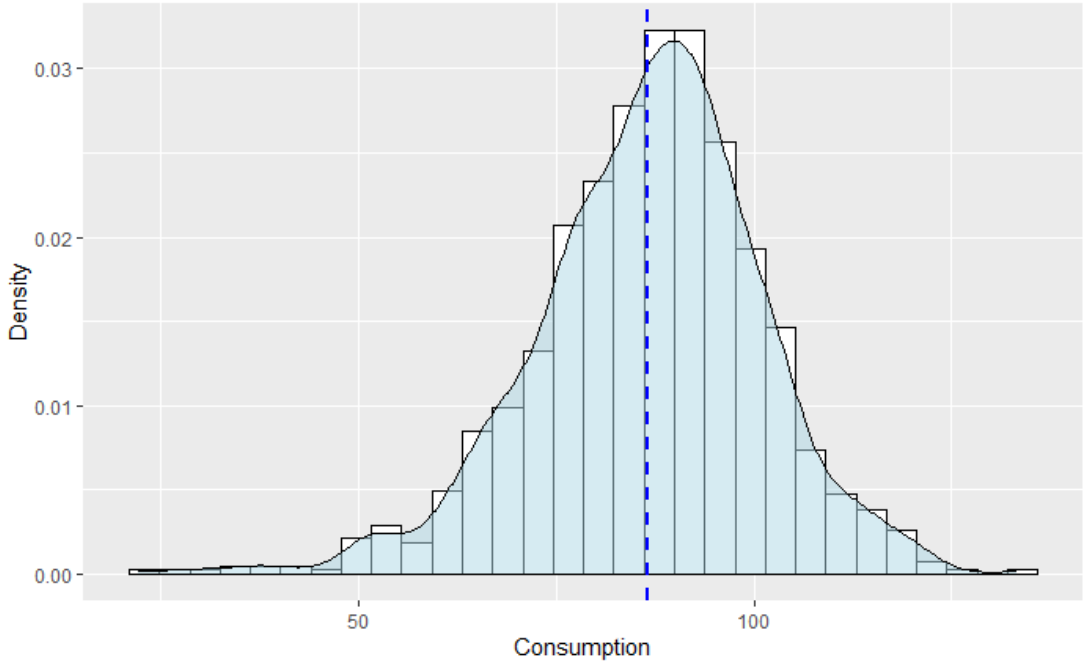
-2243.278 AIC value

Attempt to Improve:

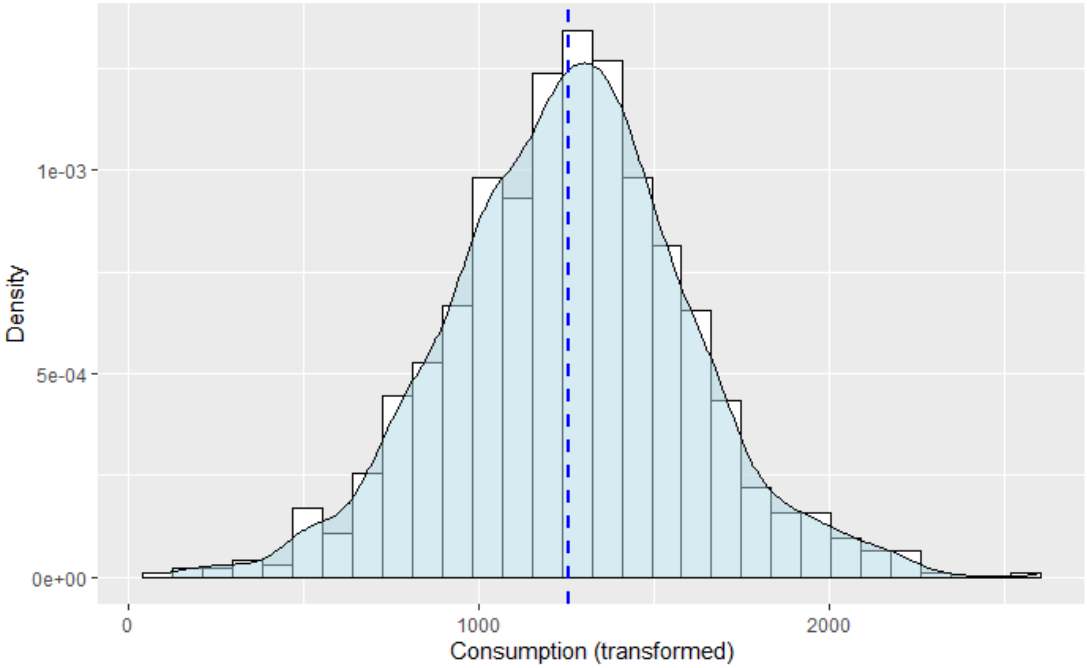


maximum lambda value = 1.717172

Considering the relationship between production and consumption of the hens may not be linear after it reaches some values, and to stabilize the variance and improve the normality of data, we use a Box-Cox transformation of consumption to see if it improves the model fitting.



The data was a little skewed before the transformation.



After transformation it is close to normal.

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Analysis of Variance Table

Response: ProductionPerHen_eggDay
                          Df Sum Sq Mean Sq  F value    Pr(>F)
ConsumptionTrans           1 0.8257 0.82569 107.4598 < 2.2e-16 ***
WeeksOfAge                 1 1.0488 1.04877 136.4928 < 2.2e-16 ***
Treatment_feeder_inch      5 0.2652 0.05303   6.9020 2.359e-06 ***
DistanceFromDoor           1 0.0793 0.07933  10.3243  0.001351 **
Tier_8                     7 0.0721 0.01031   1.3414  0.227114
DistanceFromDoor:Tier_8    7 0.1338 0.01911   2.4874  0.015483 *
Residuals               1086 8.3445 0.00768

Residual standard error: 0.08766 on 1086 degrees of freedom
Multiple R-squared:  0.2252, Adjusted R-squared:  0.2095
F-statistic: 14.34 on 22 and 1086 DF,  p-value: < 2.2e-16
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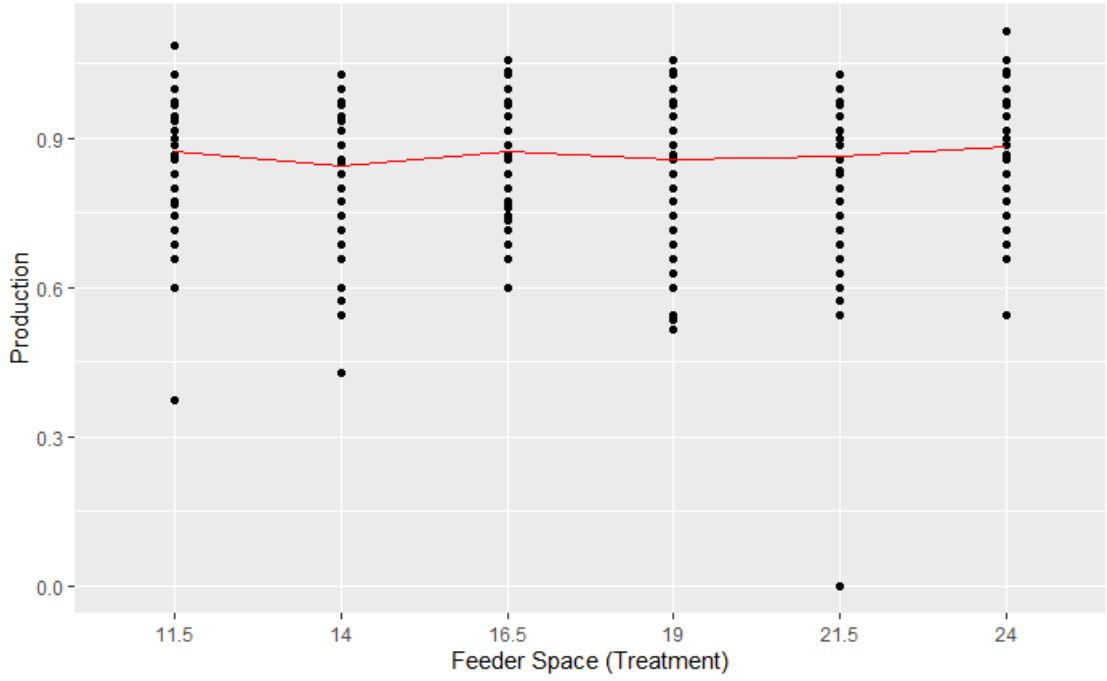
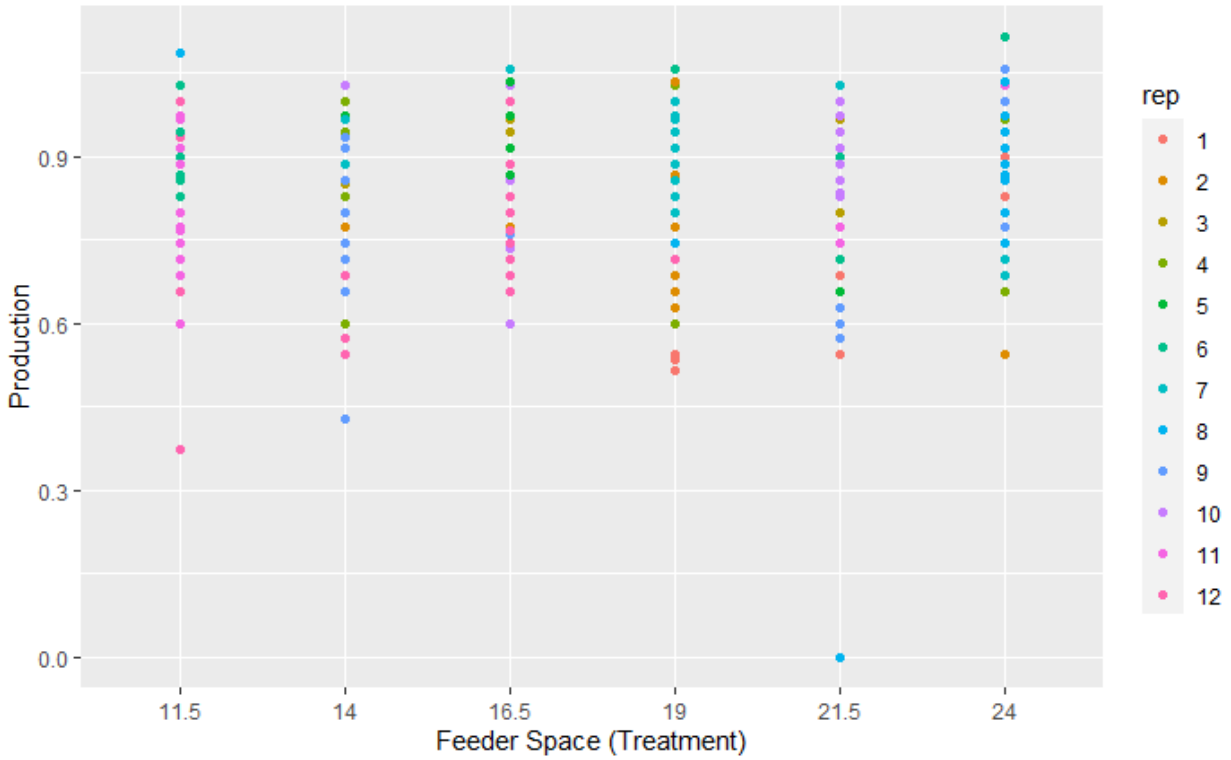
-2227.371 AIC value

The AIC value is larger than the previous model. The model before the Box-Cox transformation is preferred. (Note: AIC value could be negative, we still compare and choose models by the smaller AIC value)

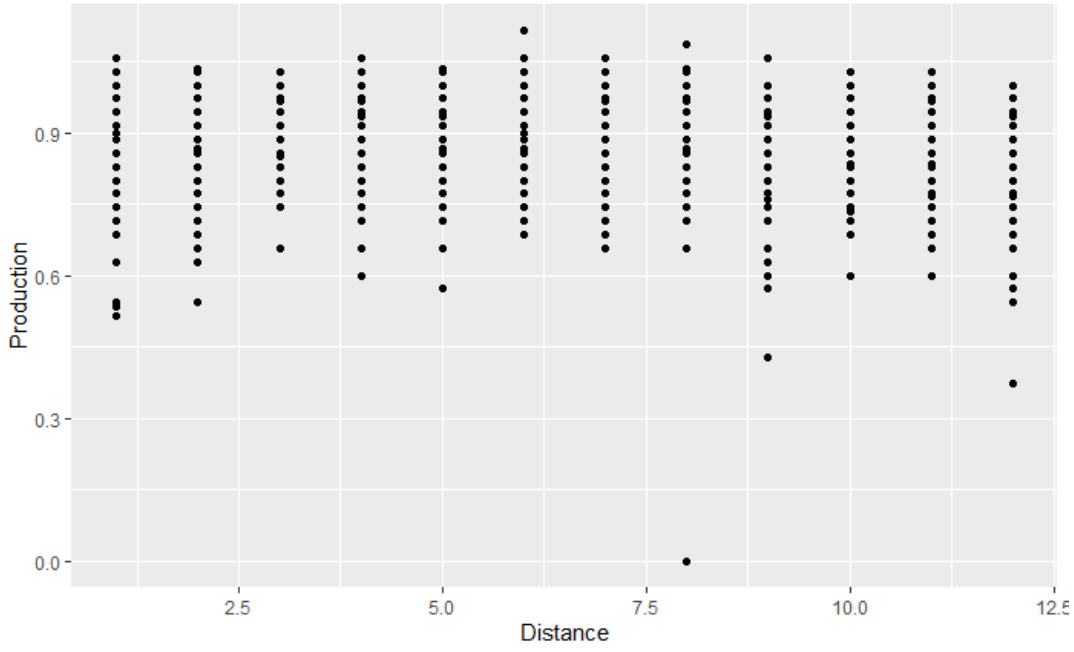
Plot Interpretation:



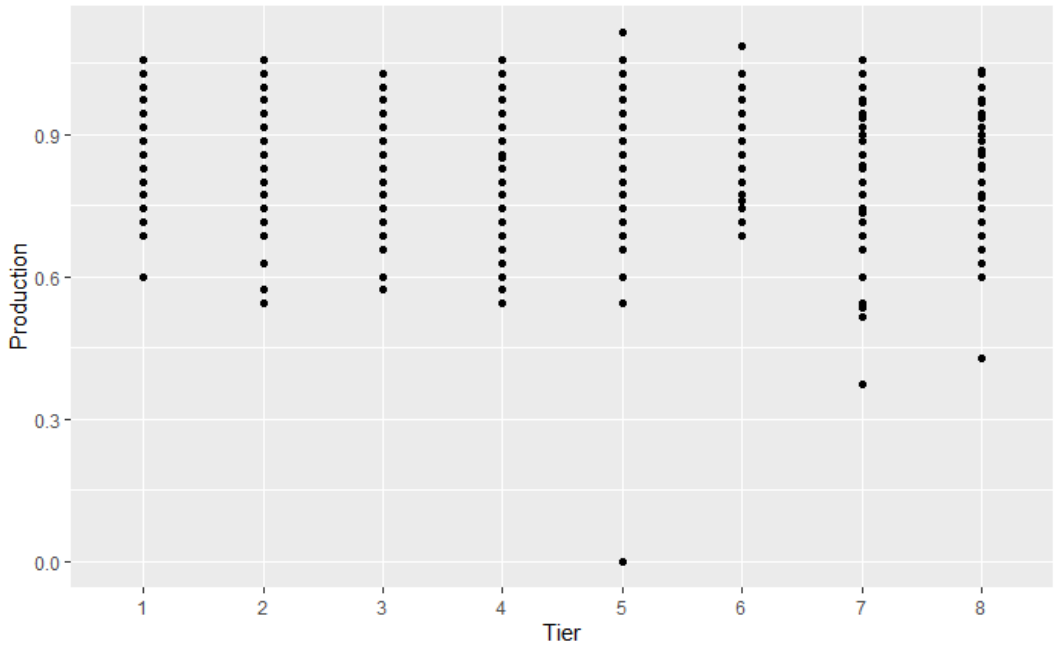
The production does not vary a lot in different levels of feeder space.



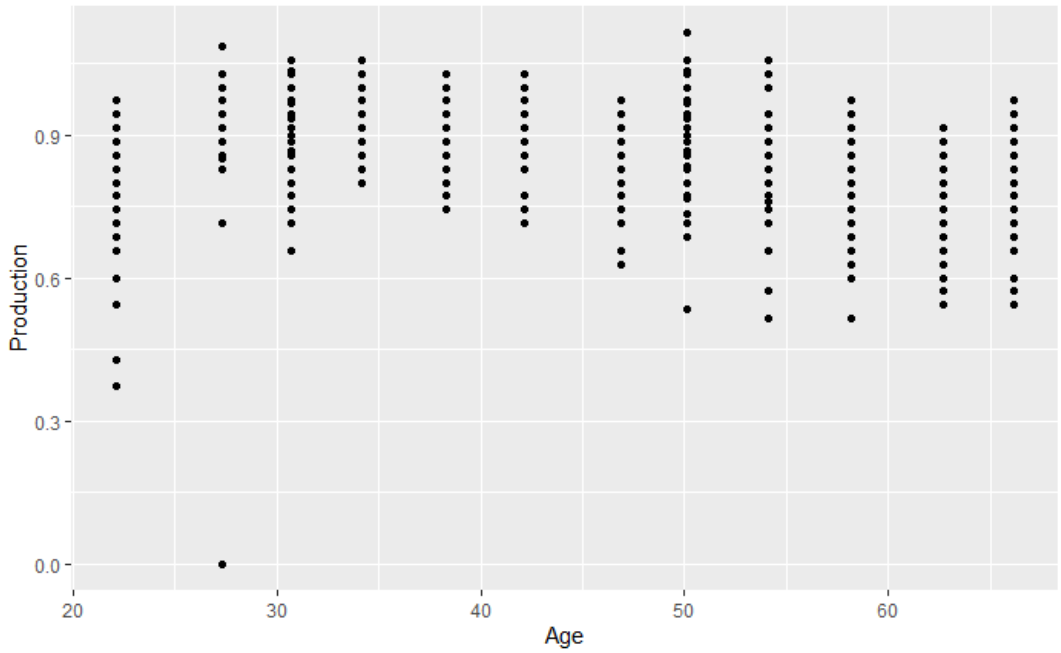
By adding colors to indicate production of cages with different distance from the door, we do not see the distance strongly affects the production.



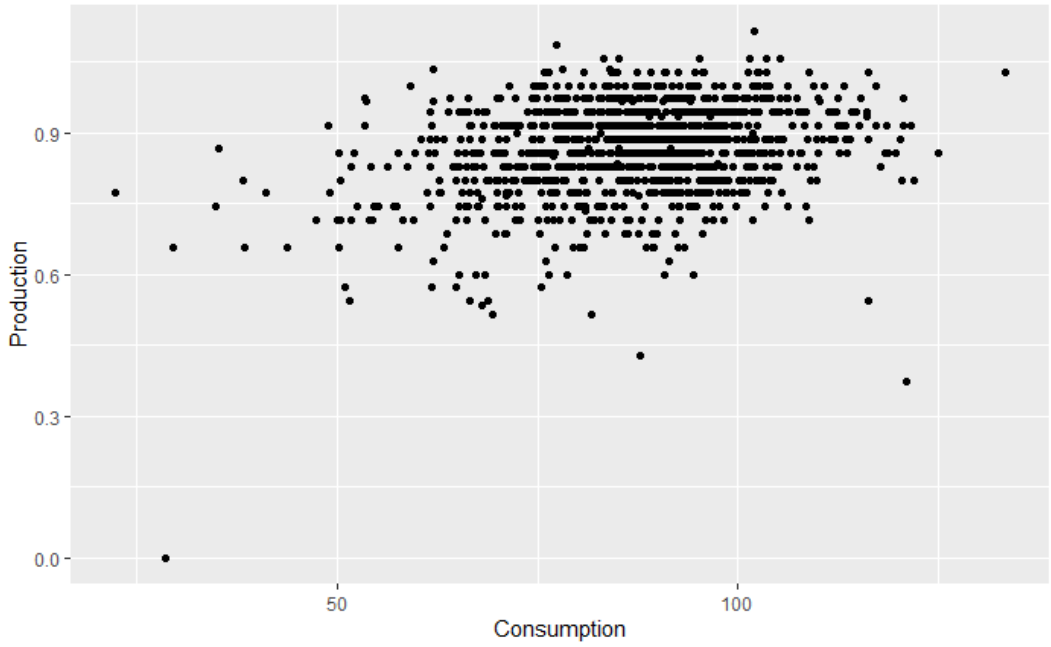
Same conclusion as above.



Tier is also not a strong factor of production.



The age of hens has some effect on the production. As the hens getting older, the production slightly decreases.



Production and consumption relationships. Not very linear in the pattern.

Conclusion:

As we find in the study, different feeder space does not affect the production much. To make production as cost effective as possible, we recommend use a smaller feeder space in the cage.