

Evaluation of Different Heuristic Optimization Techniques for the Traveling Salesman Problem

Evaluating The Ant Colony System through simulation and Data Mining

Agenda

- **Idea**
- **Methodology**
- **Data Mining Insight**
- **Analysis**
- **New Simulation**
- **Discussion**

Idea

- **Problem:**

- Too much possible values for each Parameter
- Many Parameters
- High Correlation possible between Parameters

- **Solution:**

- Ceteris Paribus - “all other things being equal”
- Monte Carlo Technique – Results through simulation

Methodology

- Iterate over all Parameters, only change one per iteration:

An:10,L:10,A:0,B:0,R:0.2,E:0

An:10,L:10,A:0,B:0,R:0.2,E:0.2

...

An:10,L:10,A:5,B:5,R:0.2,E:0

...

An:10,L:100,A:0,B:0,R:0.2,E:0

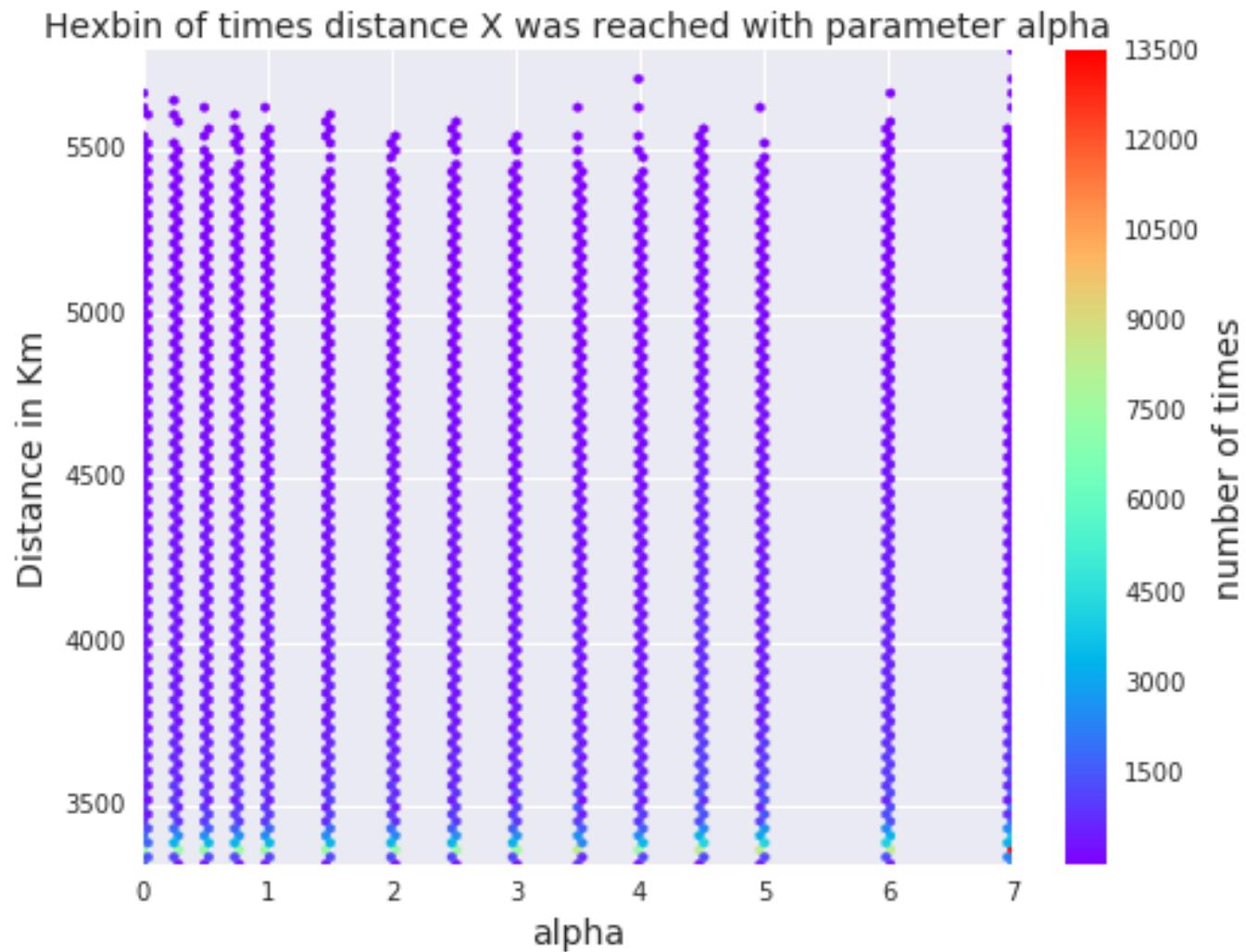
Methodology

- Generate a great number of points through simulation
- Map the effect of individual changes in the final results in seek of causality
- “All things held constant, this must be the cause”

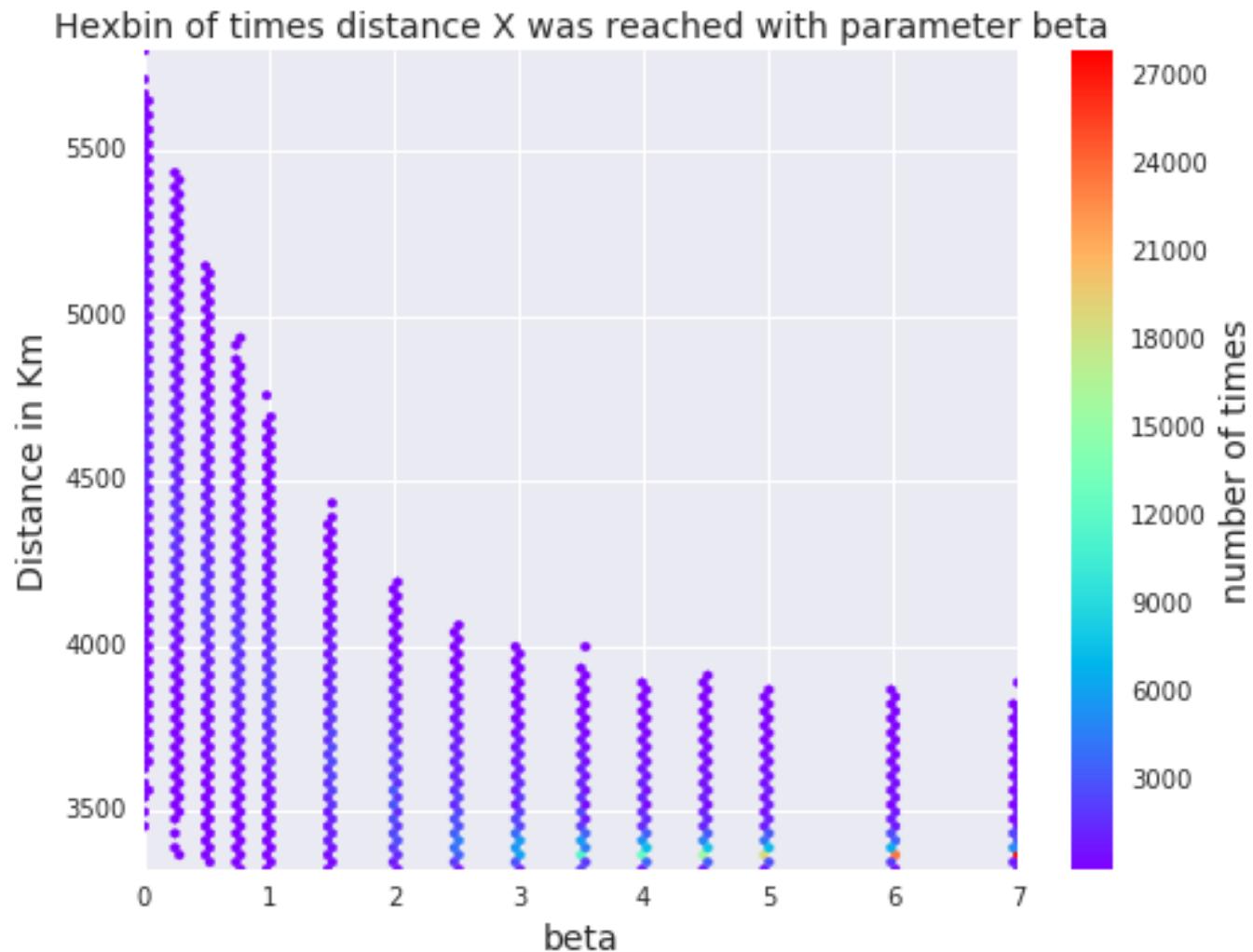
Data Mining Insight

- **Instance: Burma14**
- **Number of Cities: 14**
- **Number of Iterations: 689288**
- **Max Distance: 5806 km**
- **50%Q Distance: 3560 km**
- **Min Distance: 3323 km**
- **Mean Distance: 3753 km**
- **Mode Distance: 3371 km**
- **Optimal Distance: 3323 km**

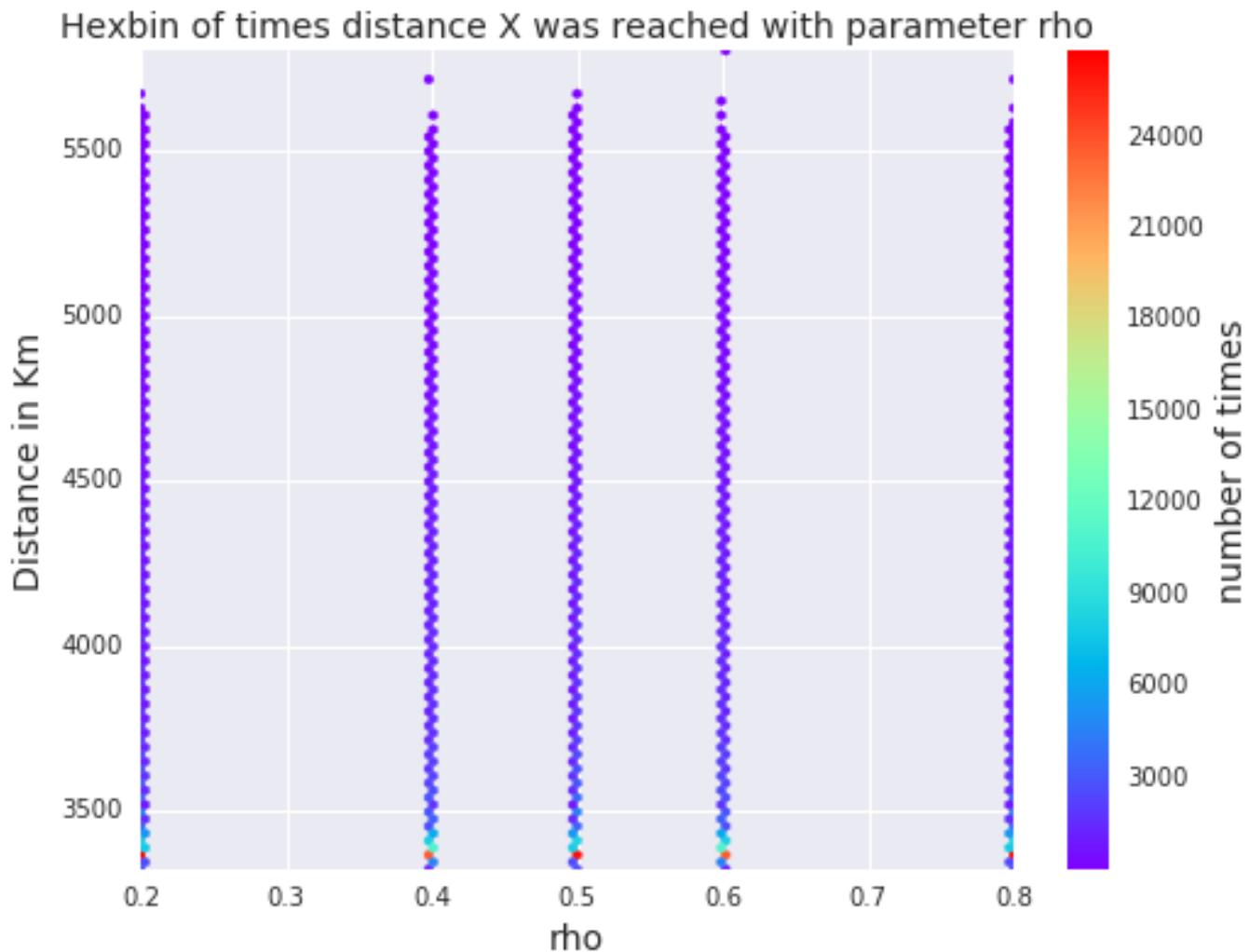
Analysis - Hexagram



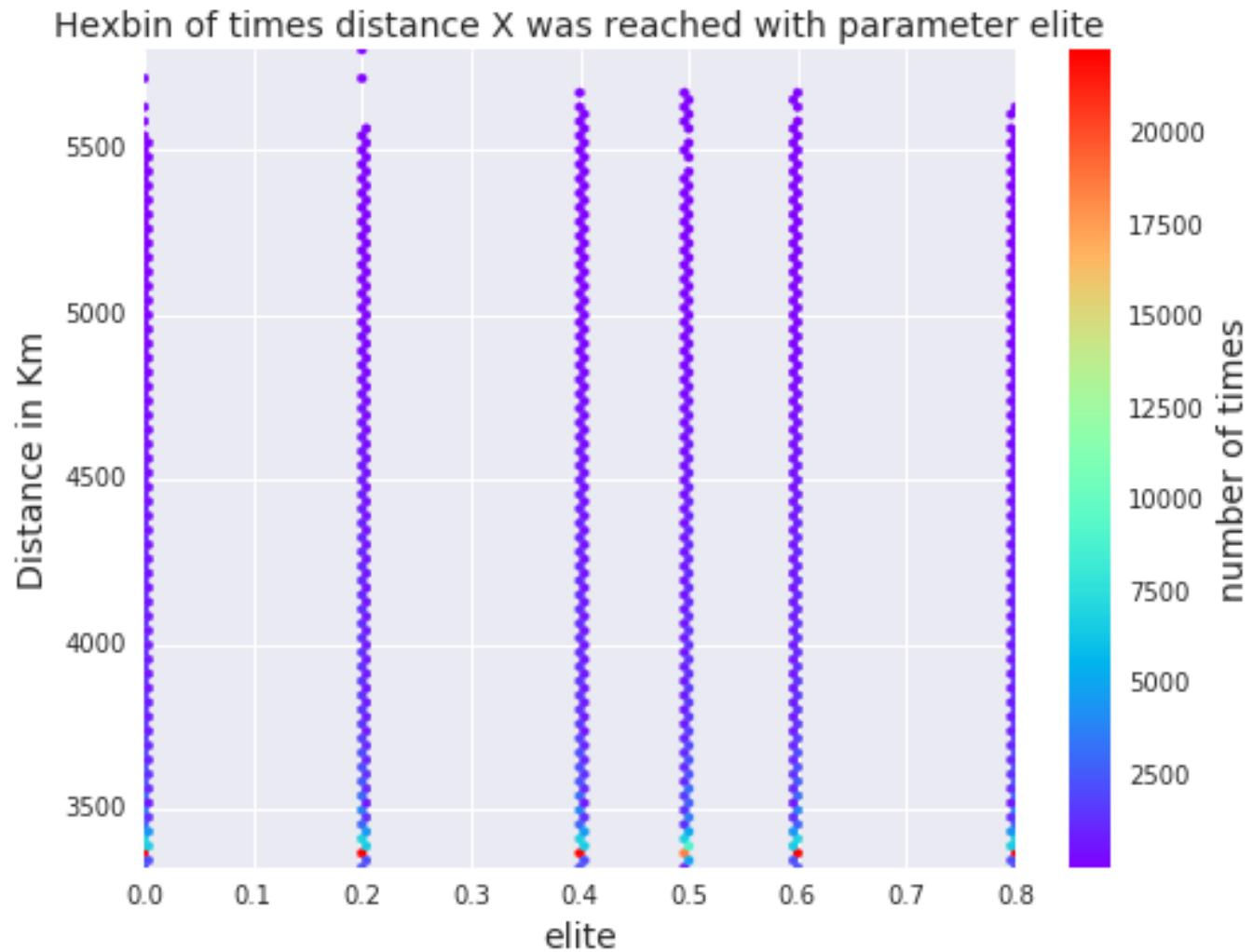
Analysis - Hexagram



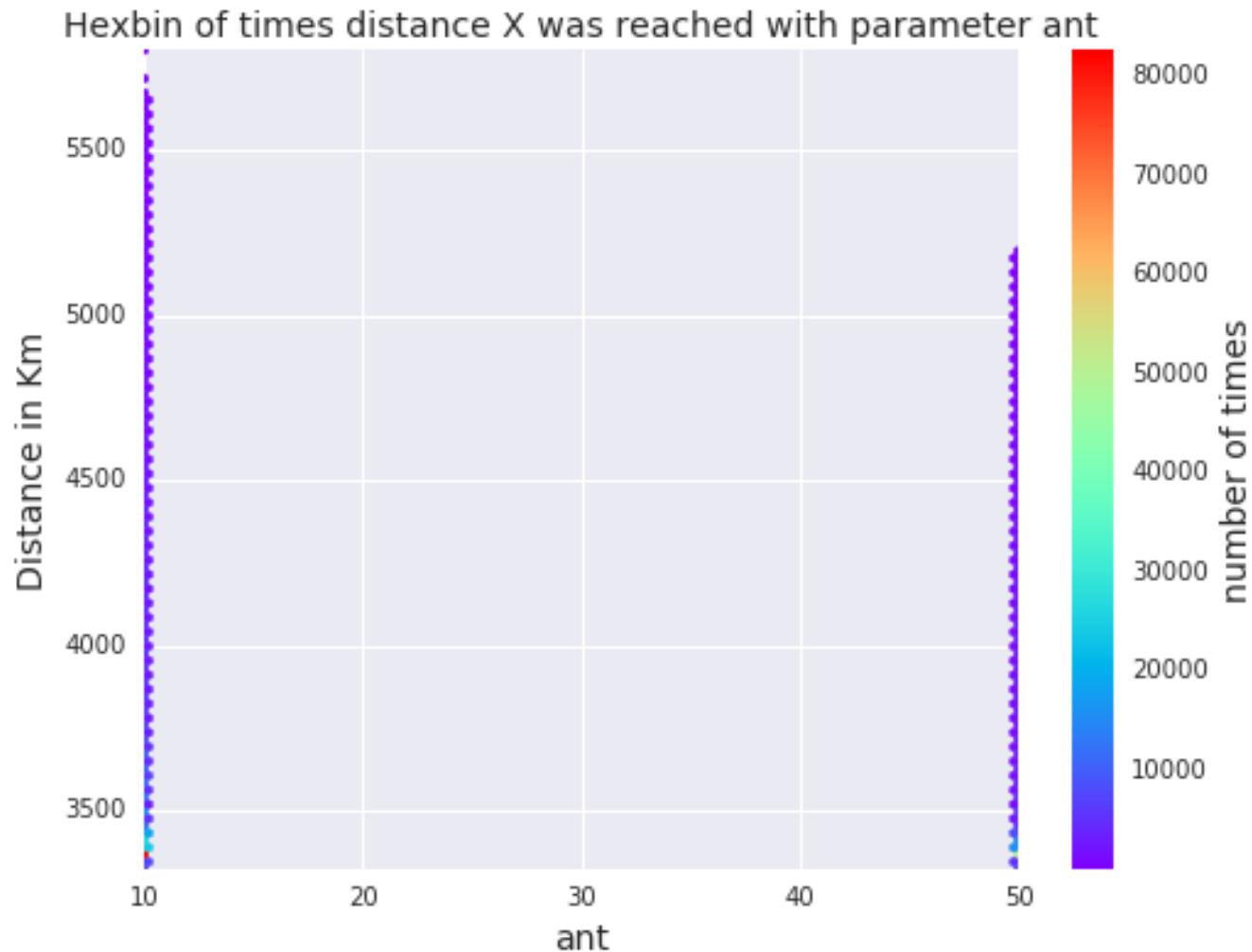
Analysis - Hexagram



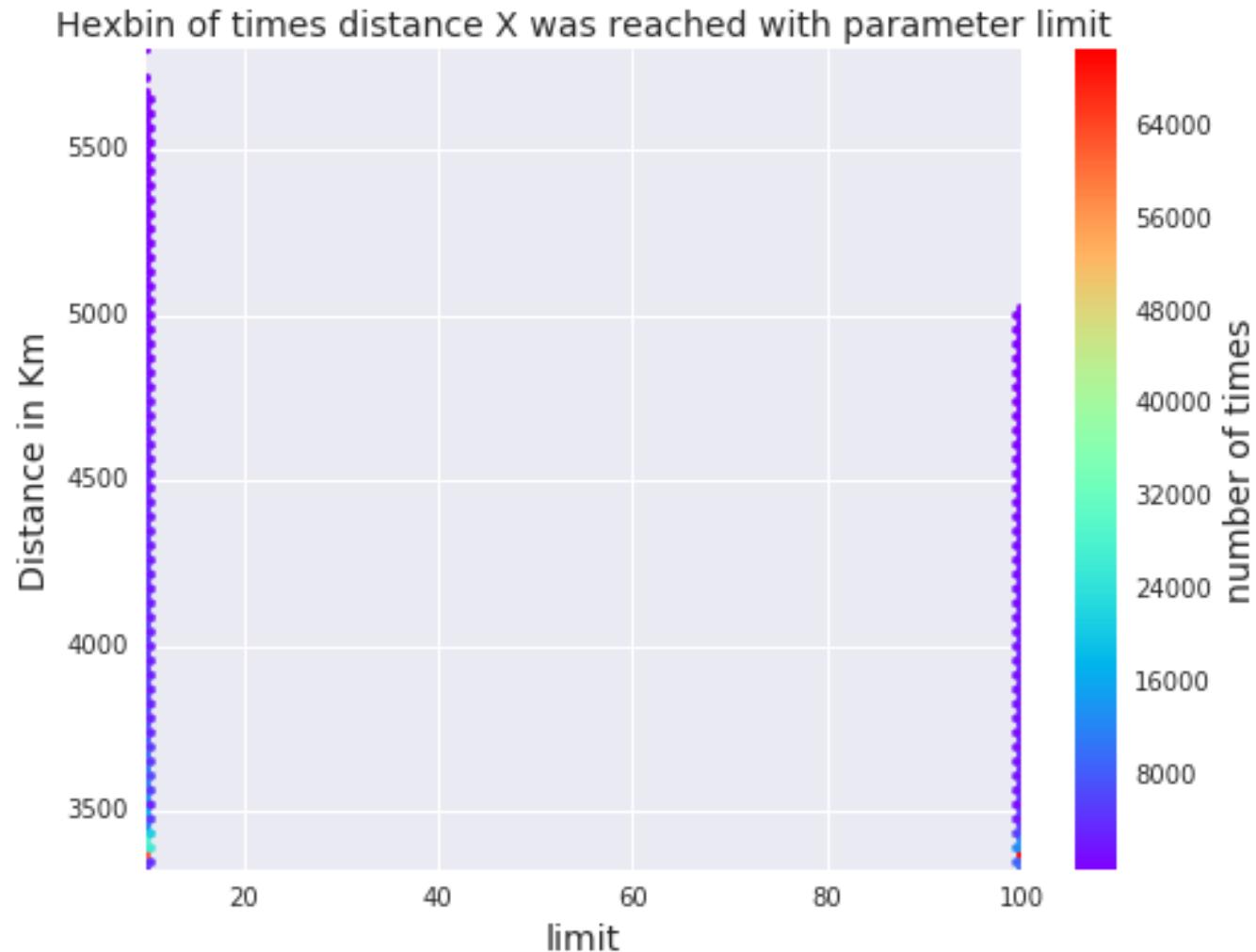
Analysis - Hexagram



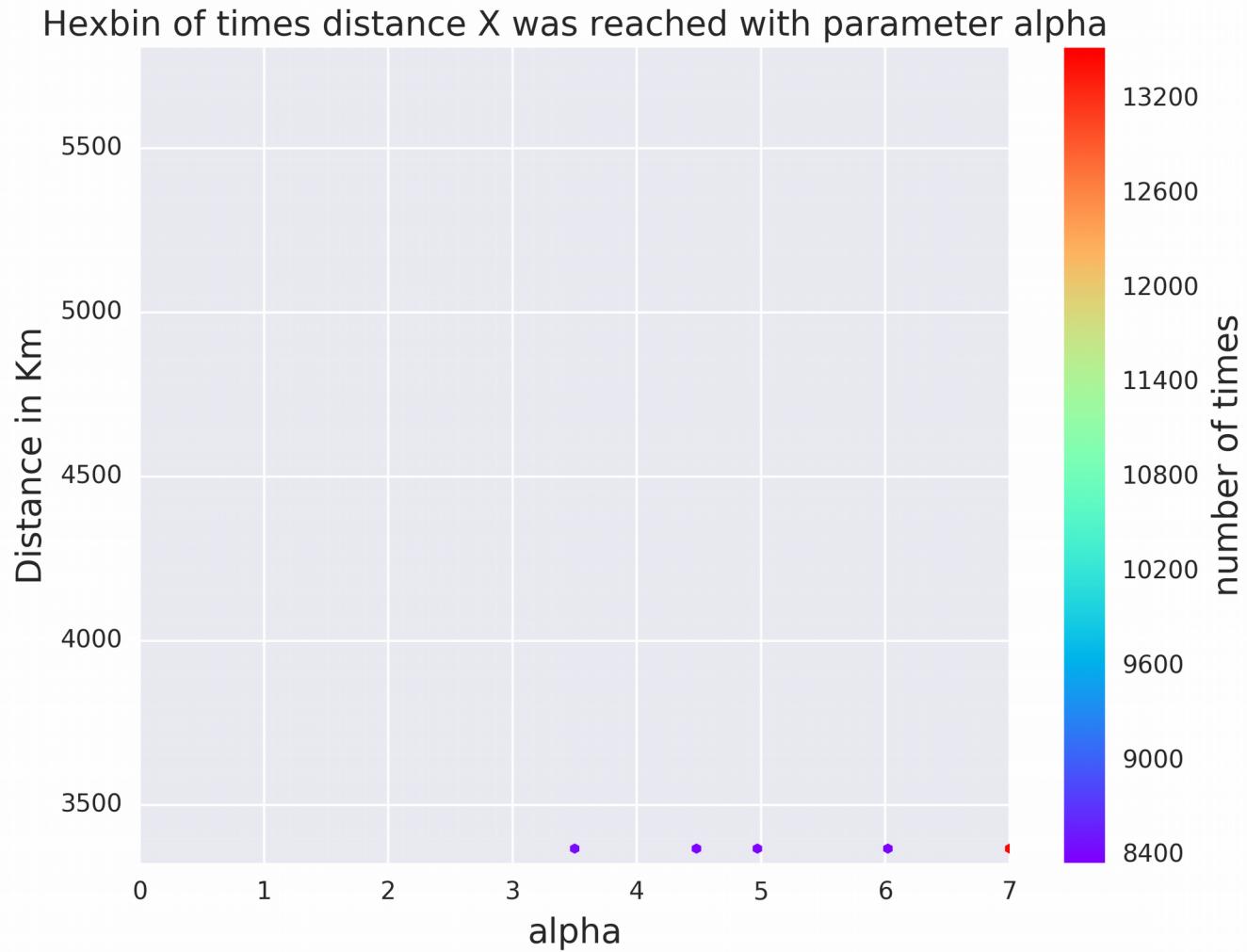
Analysis - Hexagram



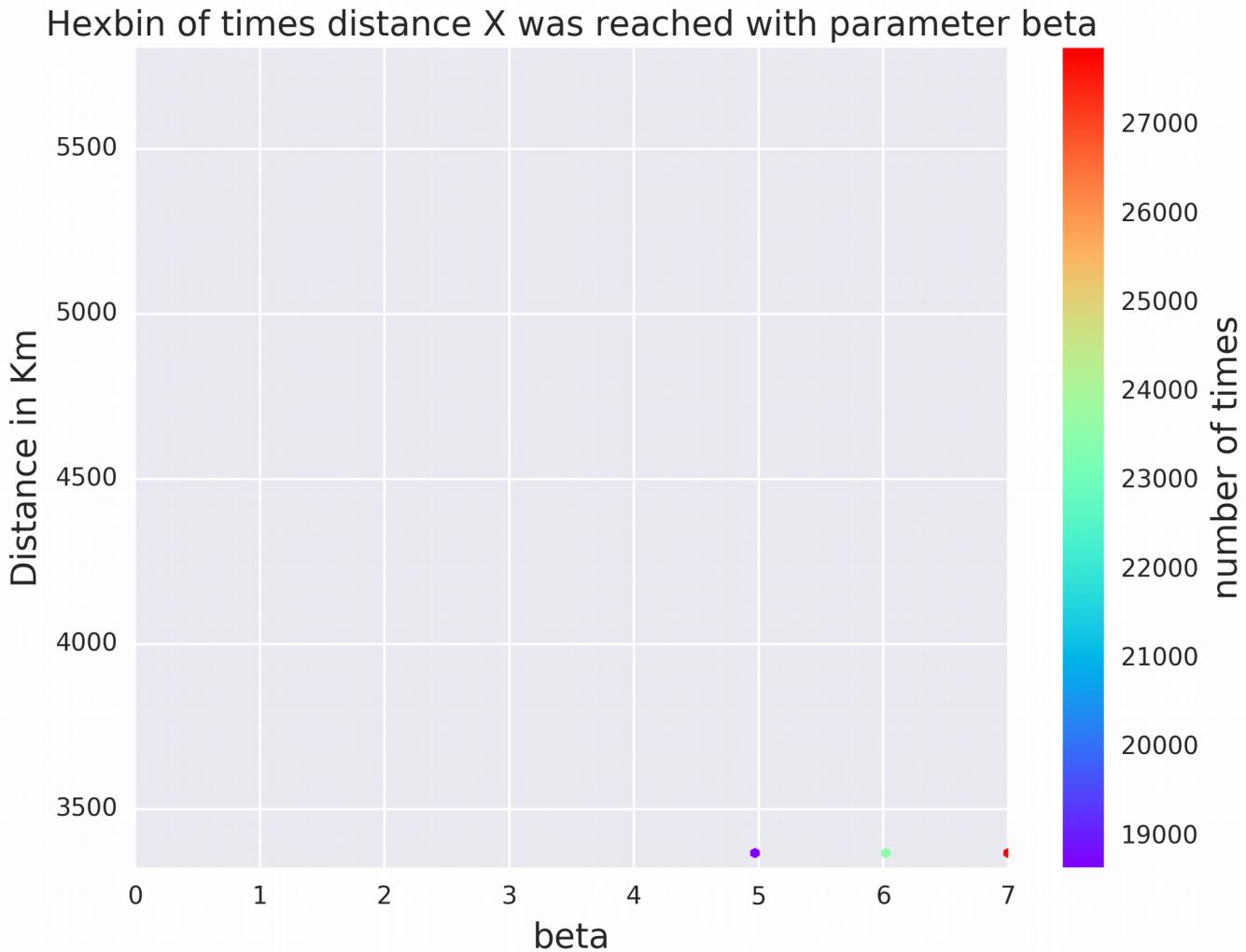
Analysis - Hexagram



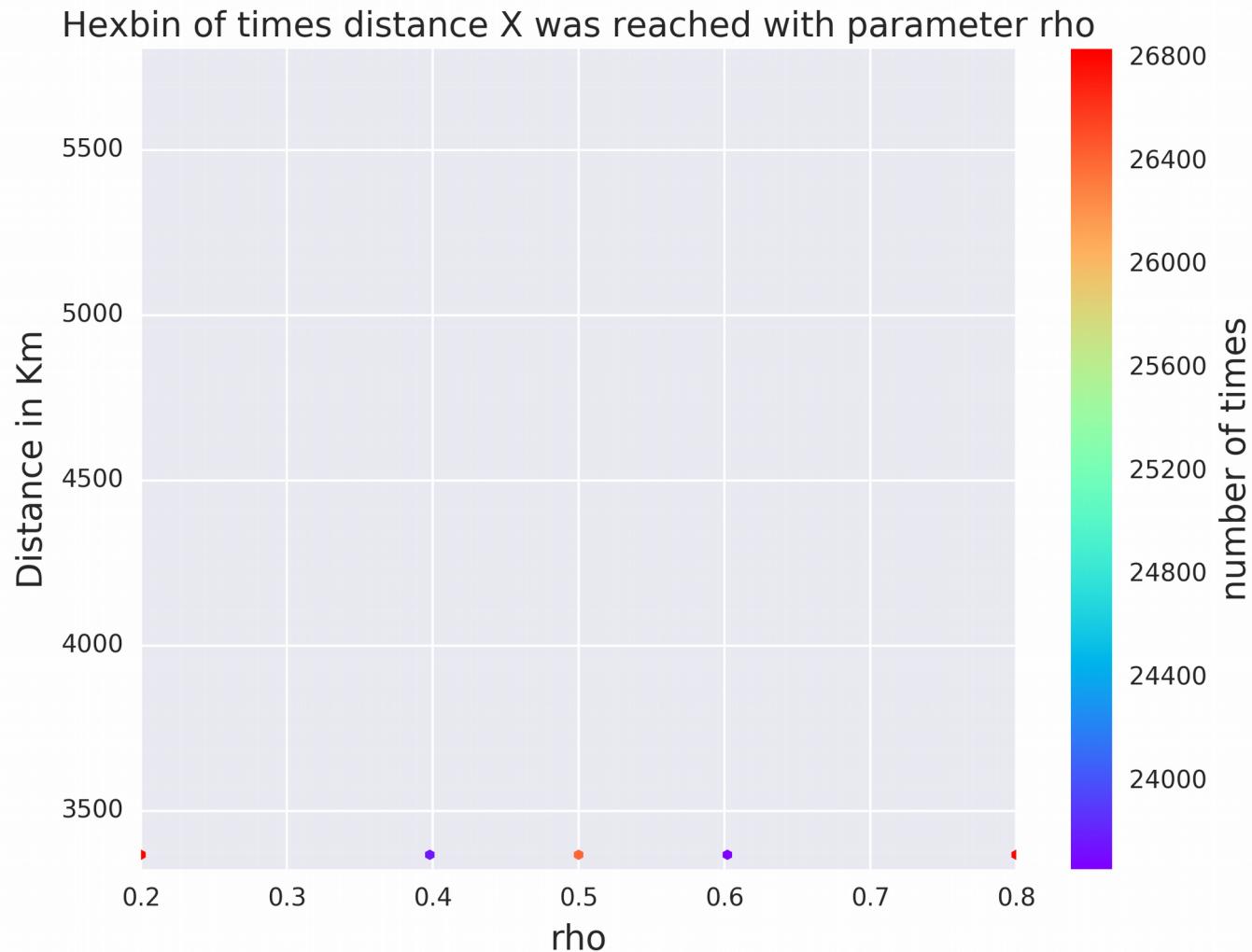
Hexagram - Refining



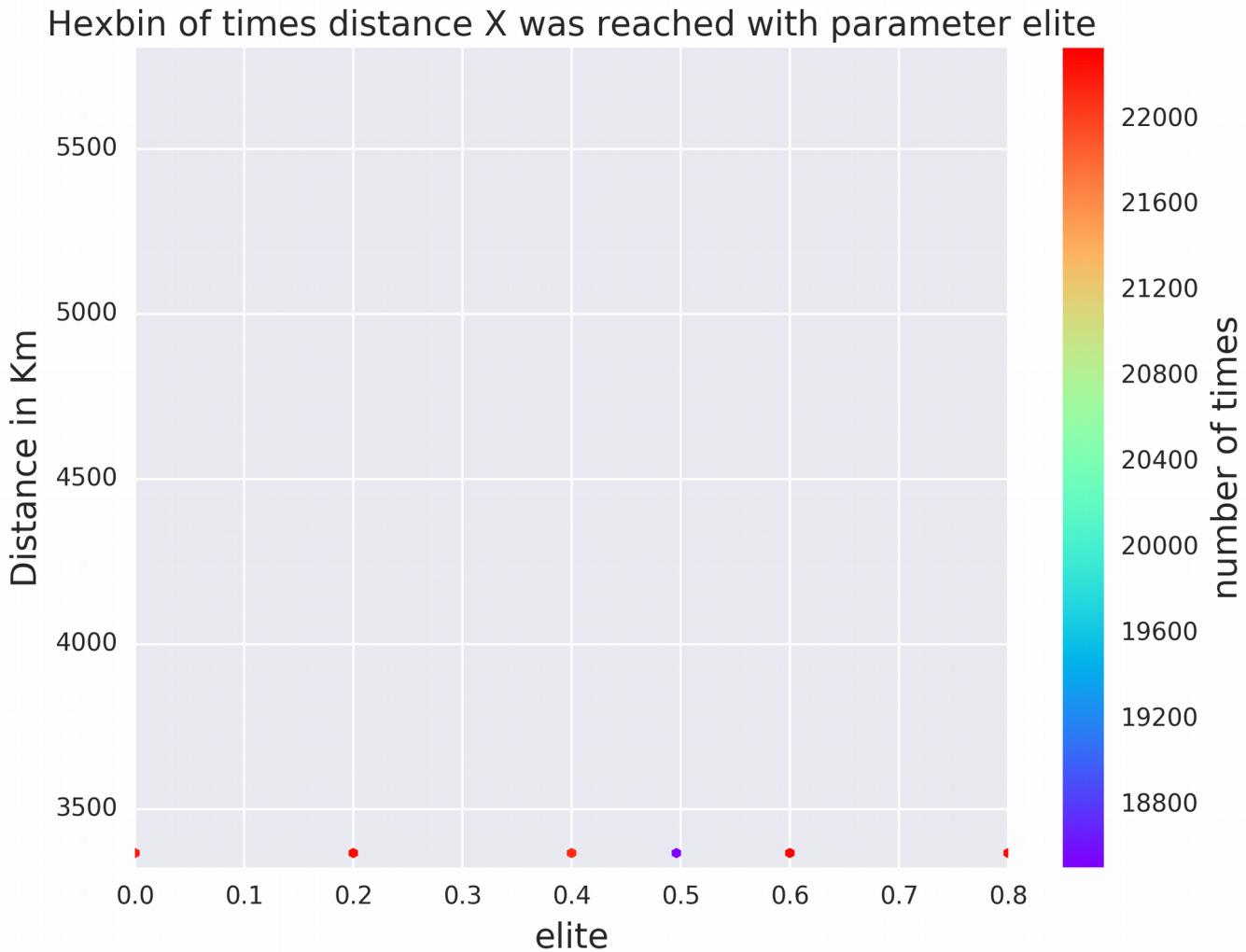
Hexagram - Refining



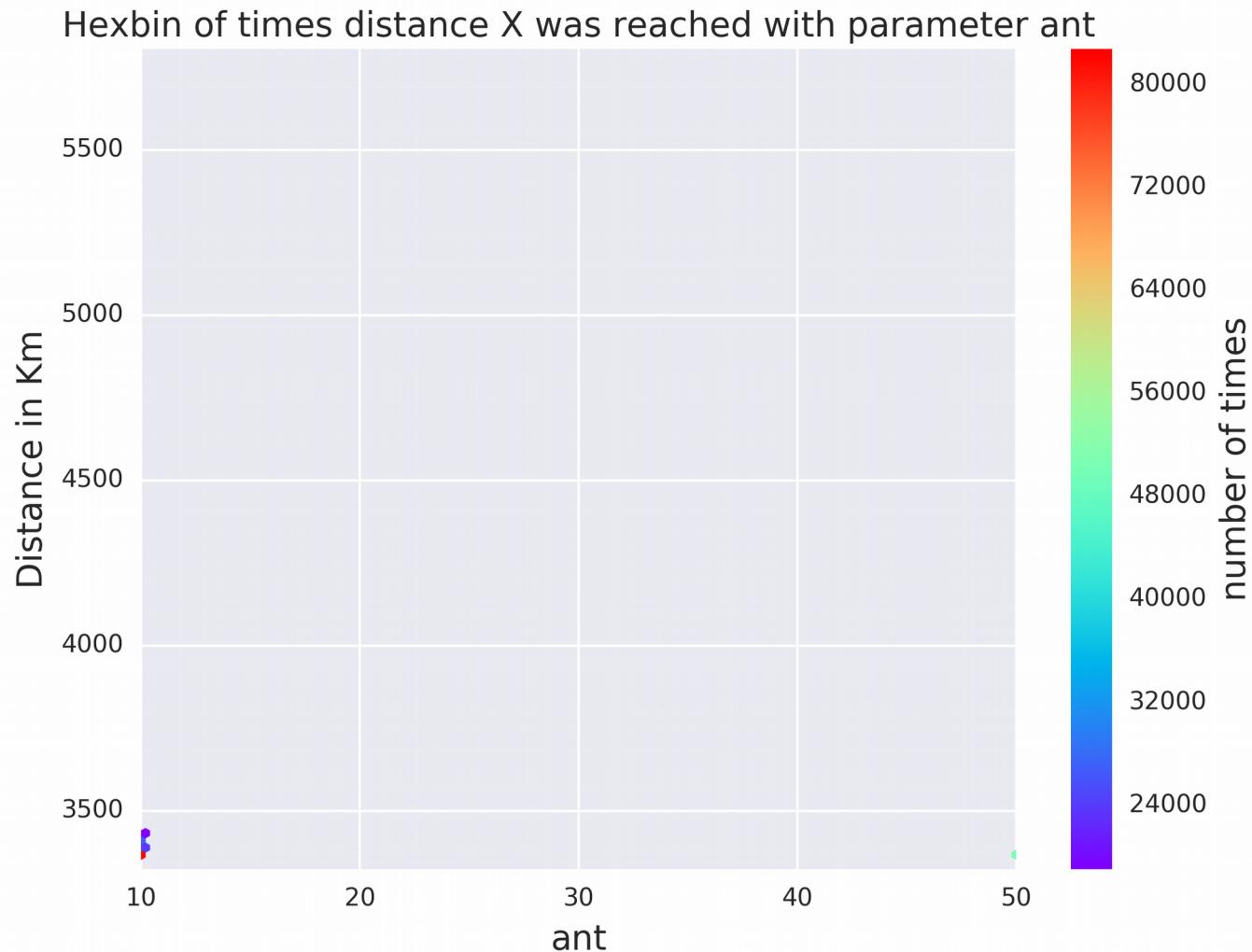
Hexagram - Refining



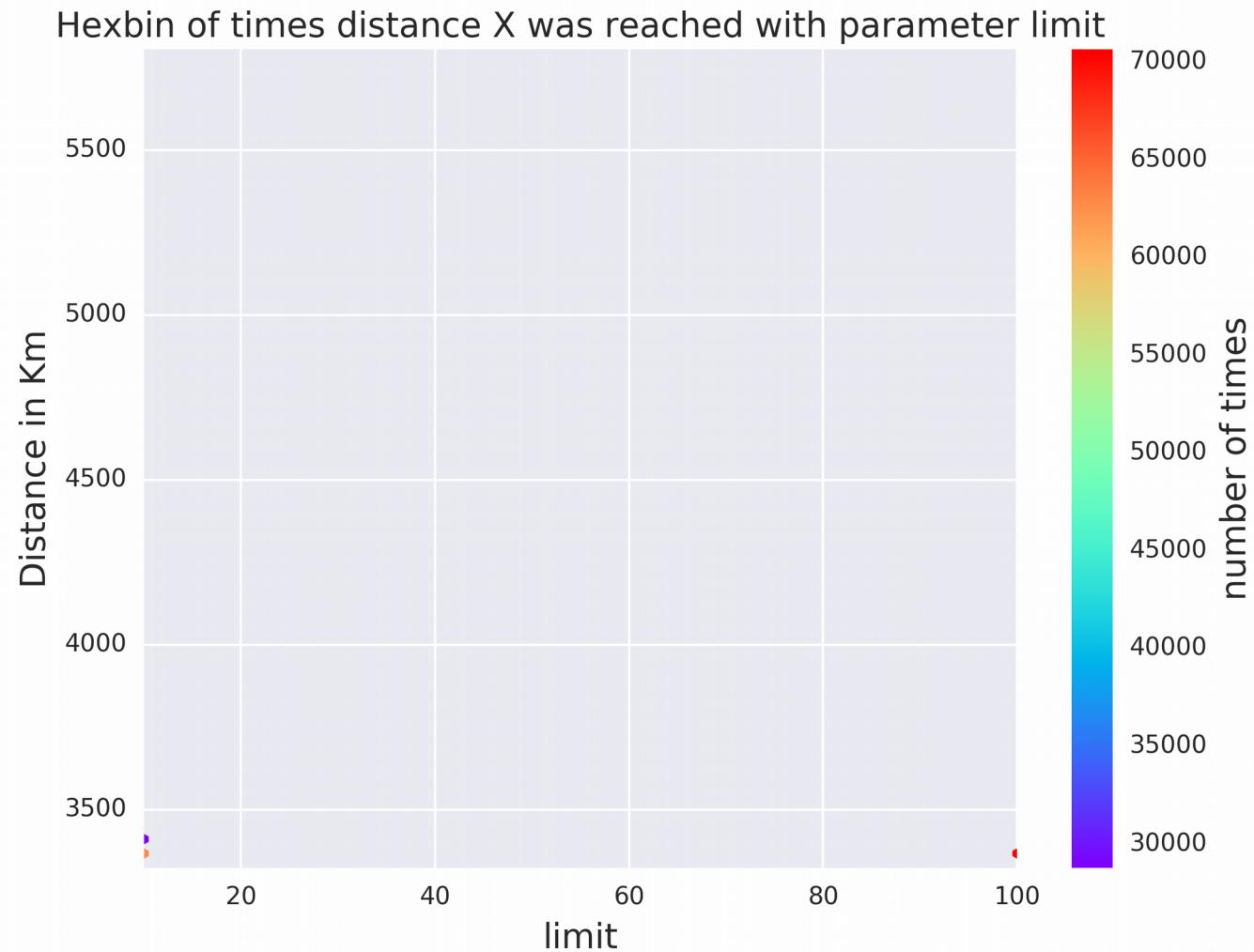
Hexagram - Refining



Hexagram - Refining



Hexagram - Refining



Initial Results

Through the analysis of the Hexagrams, the results should be:

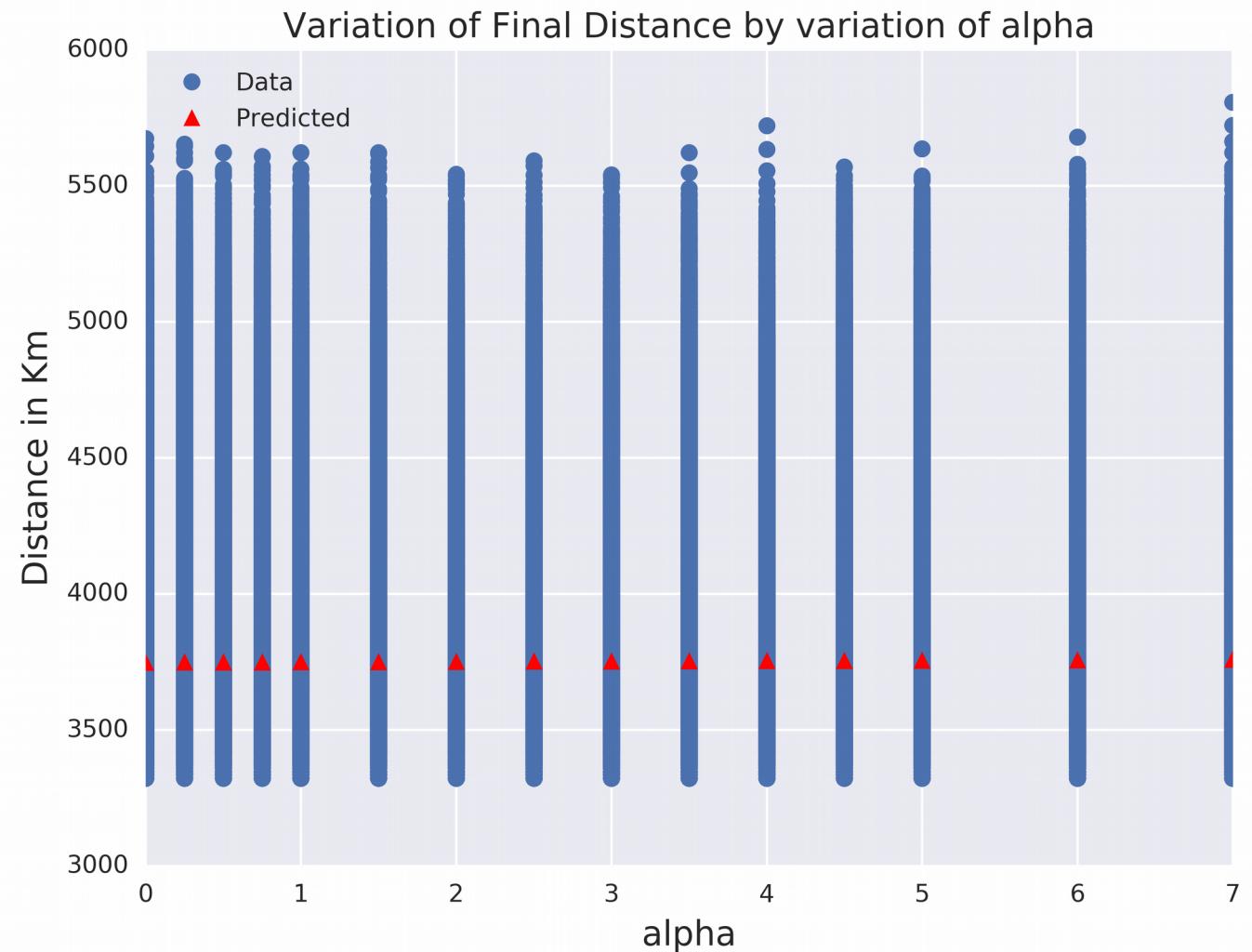
- Alpha: 7
- Beta: 7
- Rho: 0.2, 0.5, 0.8
- Elite: 0.6
- Ant: 10 ~ 50
- Limit: 100

Statistical Analysis - Linear Model

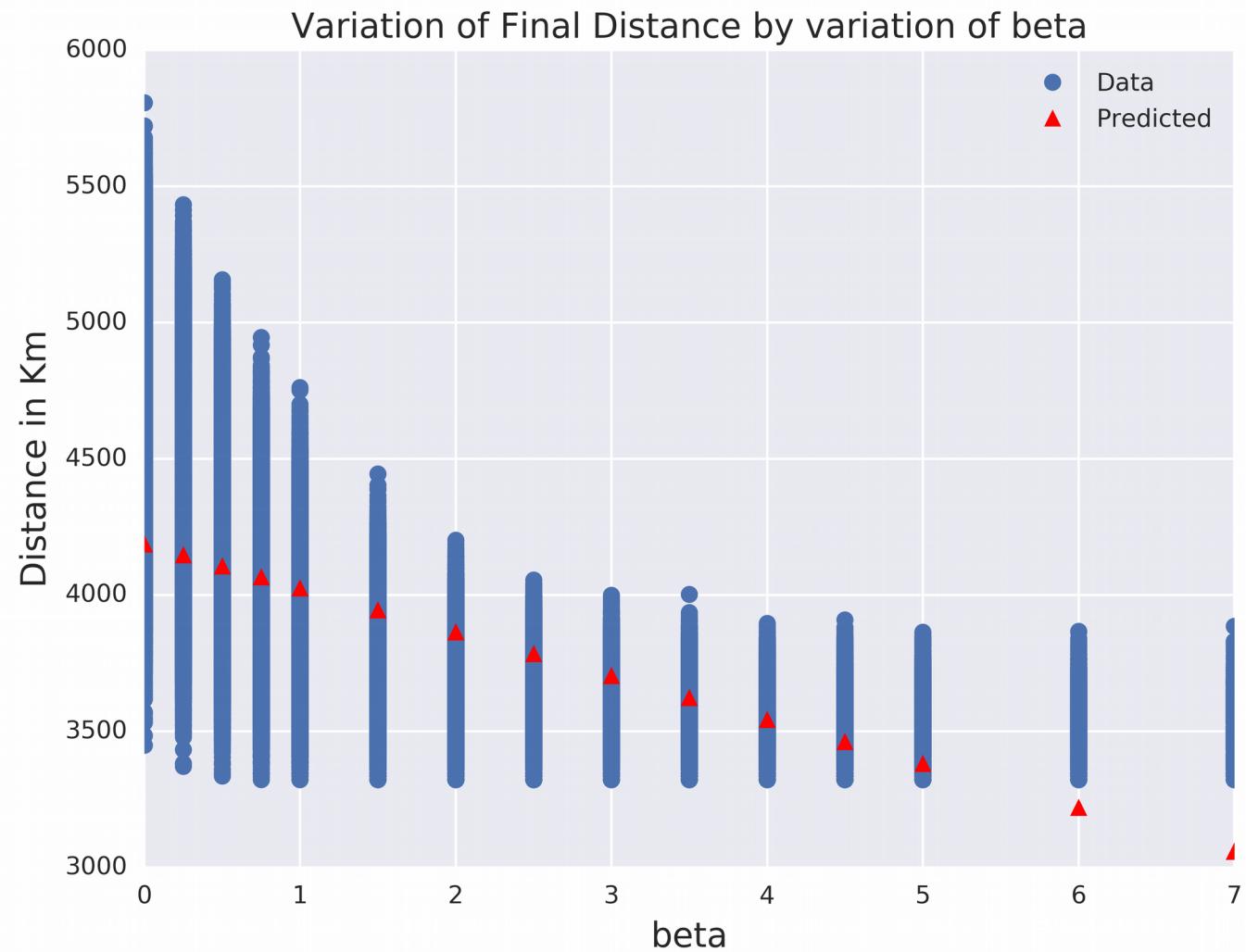
Parameter	R ²	%	Pearson Corr	Spearman Corr
Alpha	0.00005	0.00	0.0070	0.0160
Beta	0.5713	57.13	-0.7559	-0.8566
Rho	0.000004	0.00	-0.0020	-0.0019
Elite	0.000005	0.00	-0.0021	-0.0022
Ant	0.0048	0.48	-0.0696	-0.0756
Limit	0.0326	3.26	-0.1808	-0.2291

Why is our explanation so distant of the correlation?
Our model must not be linear.

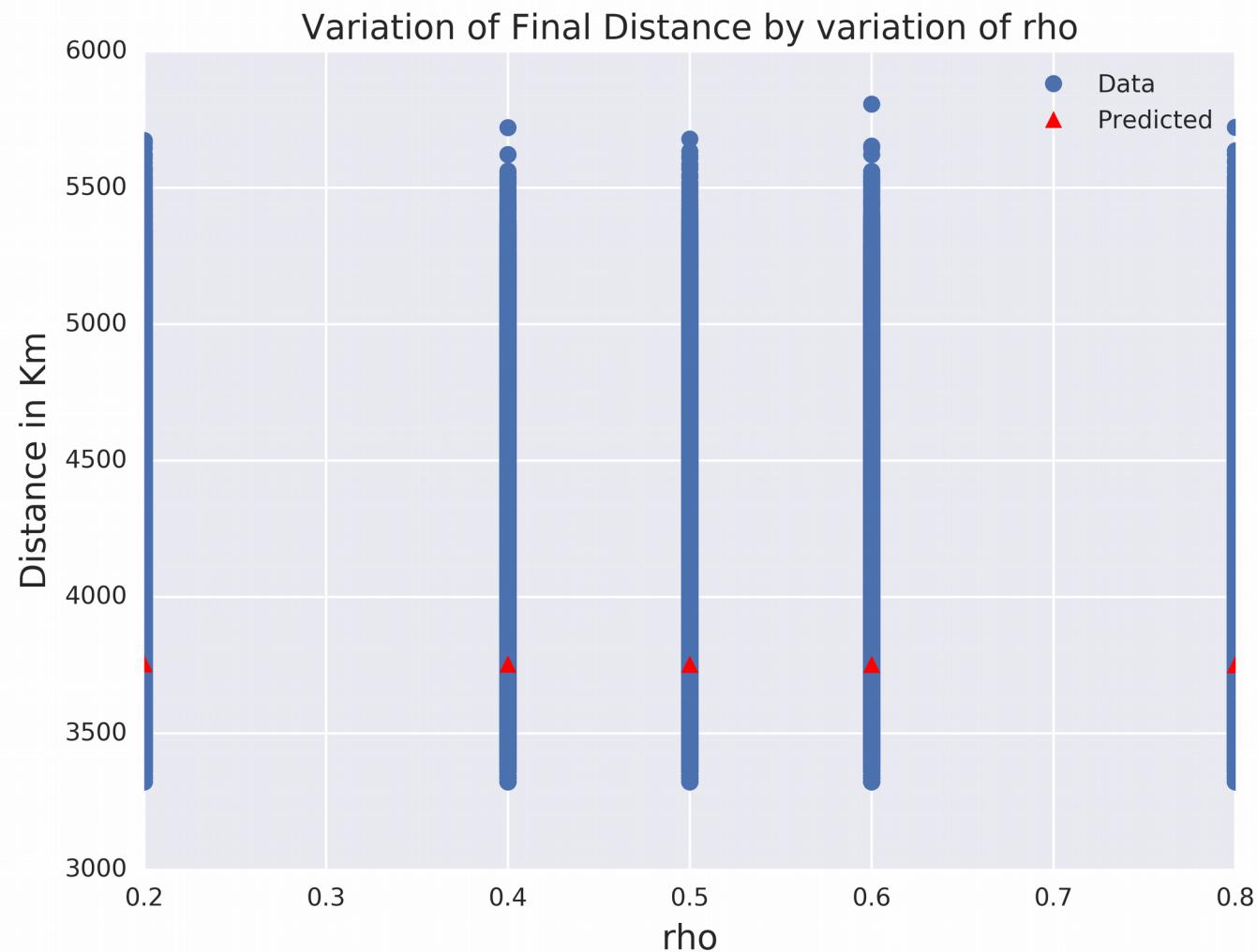
Category Model



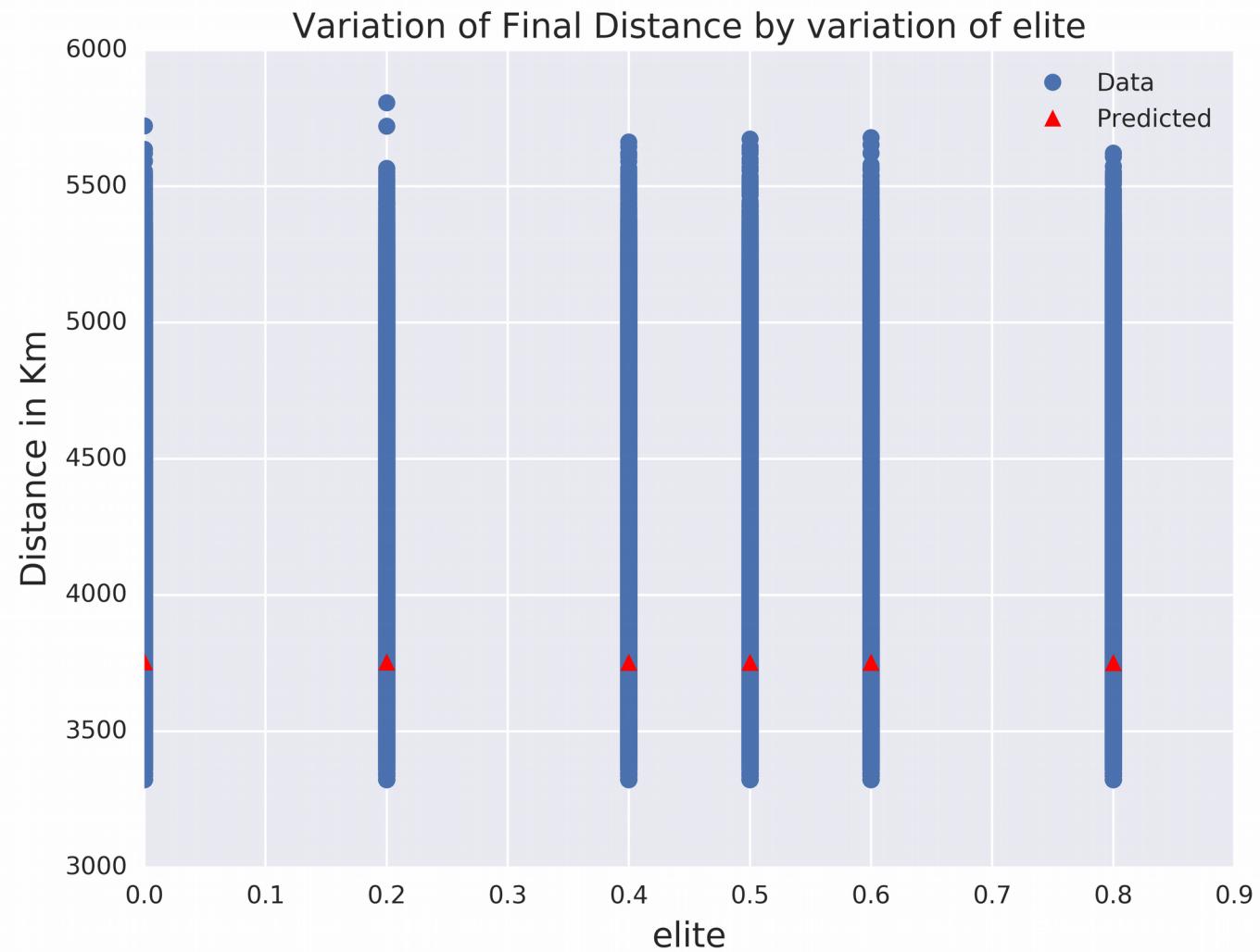
Category Model



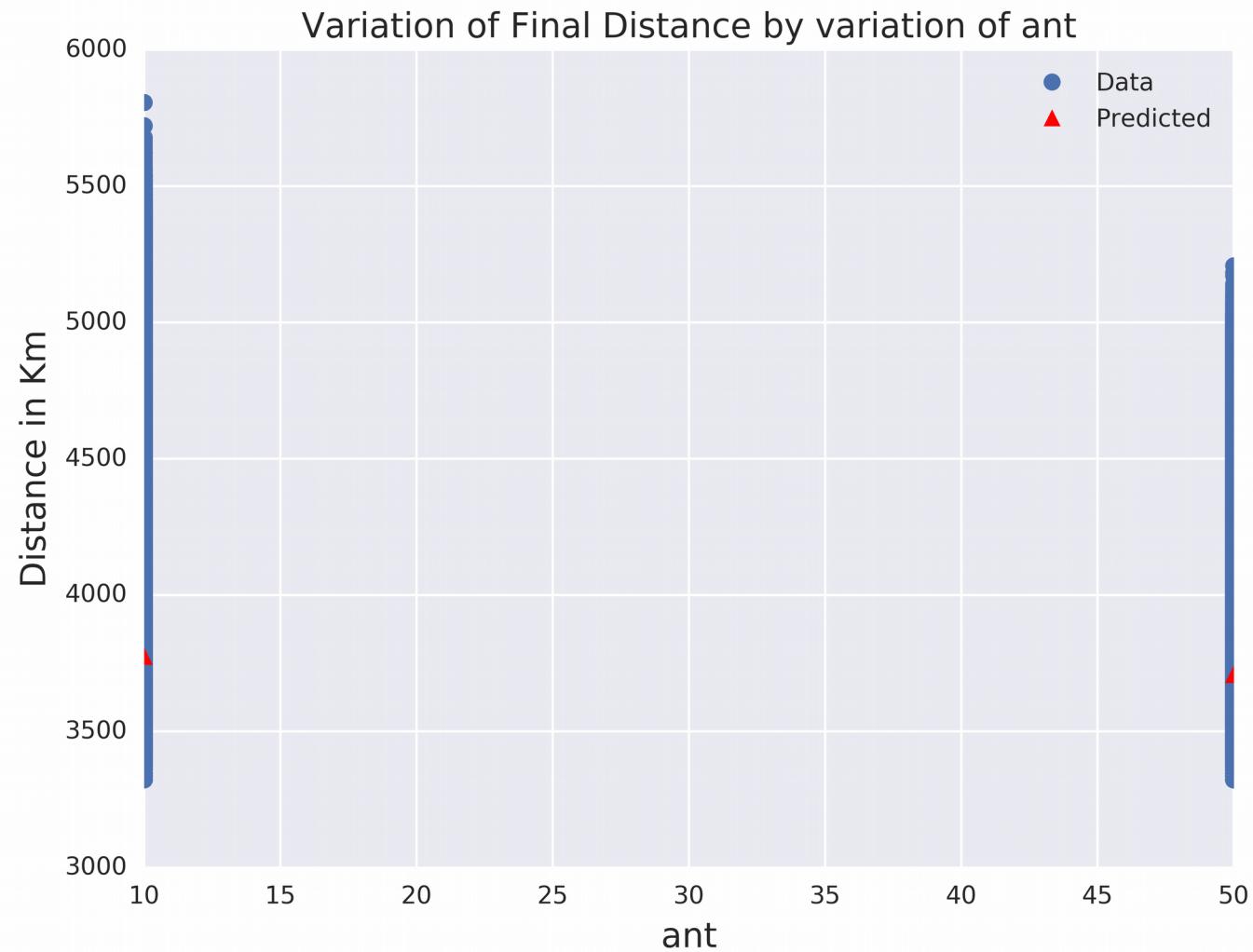
Category Model



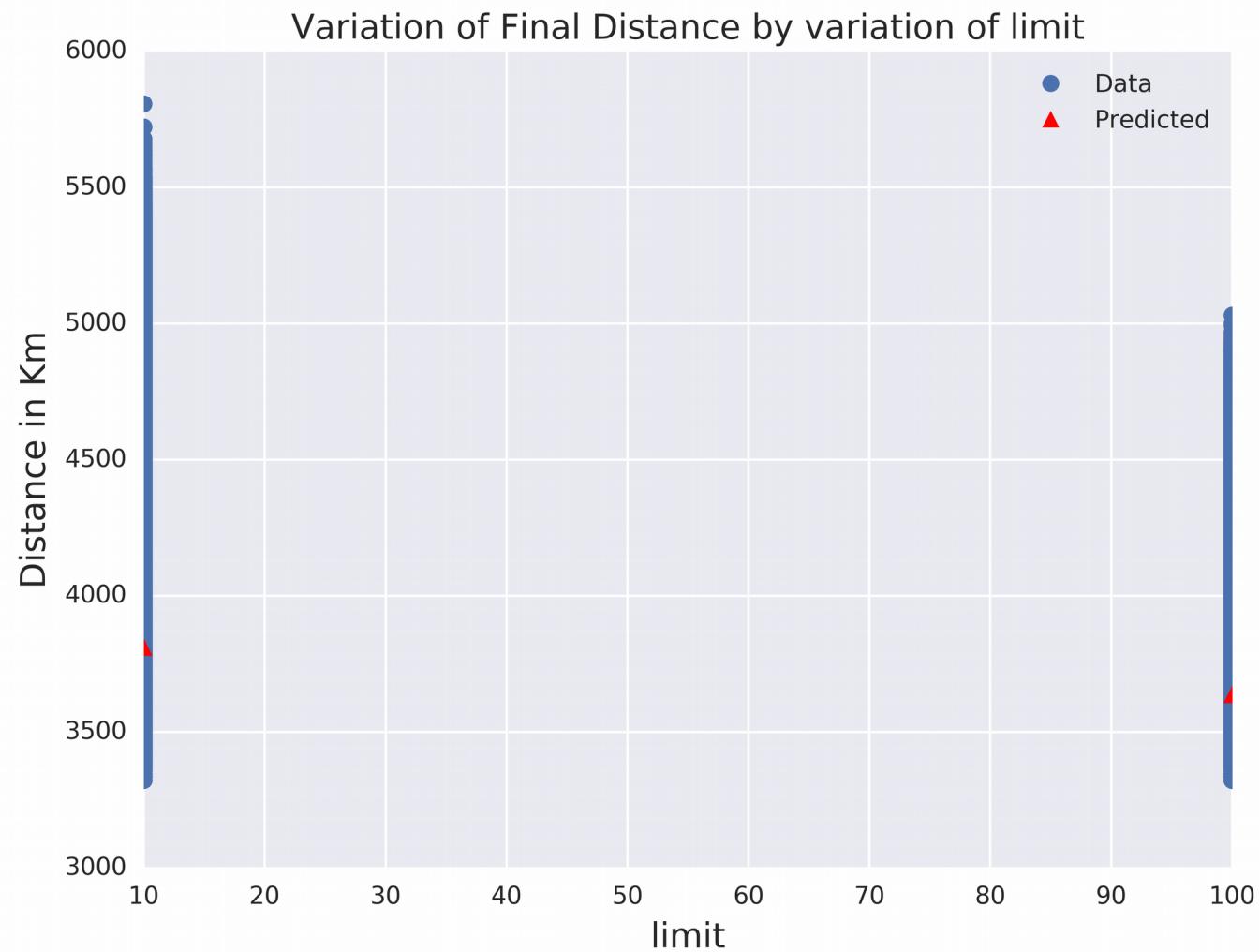
Category Model



Category Model



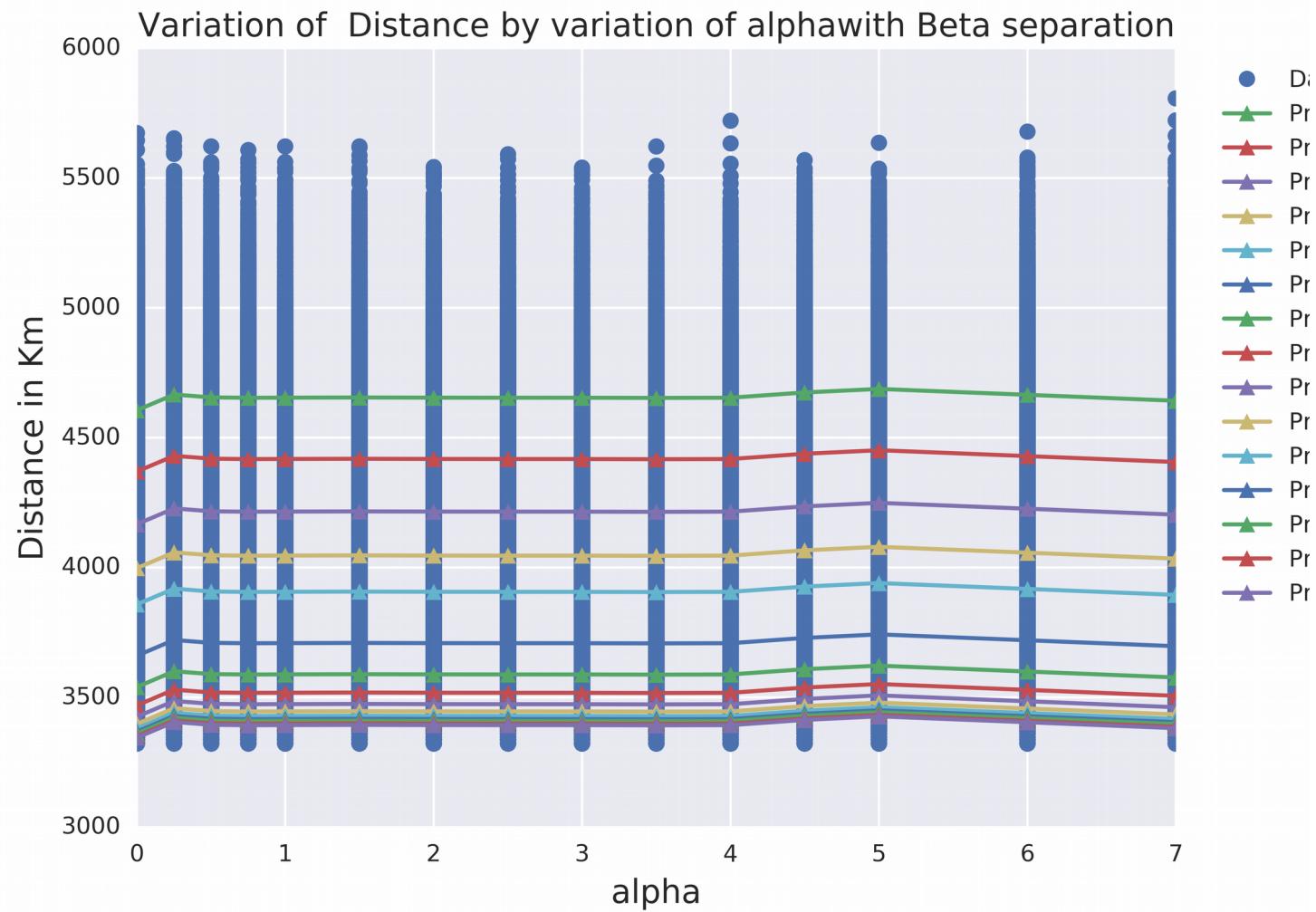
Category Model



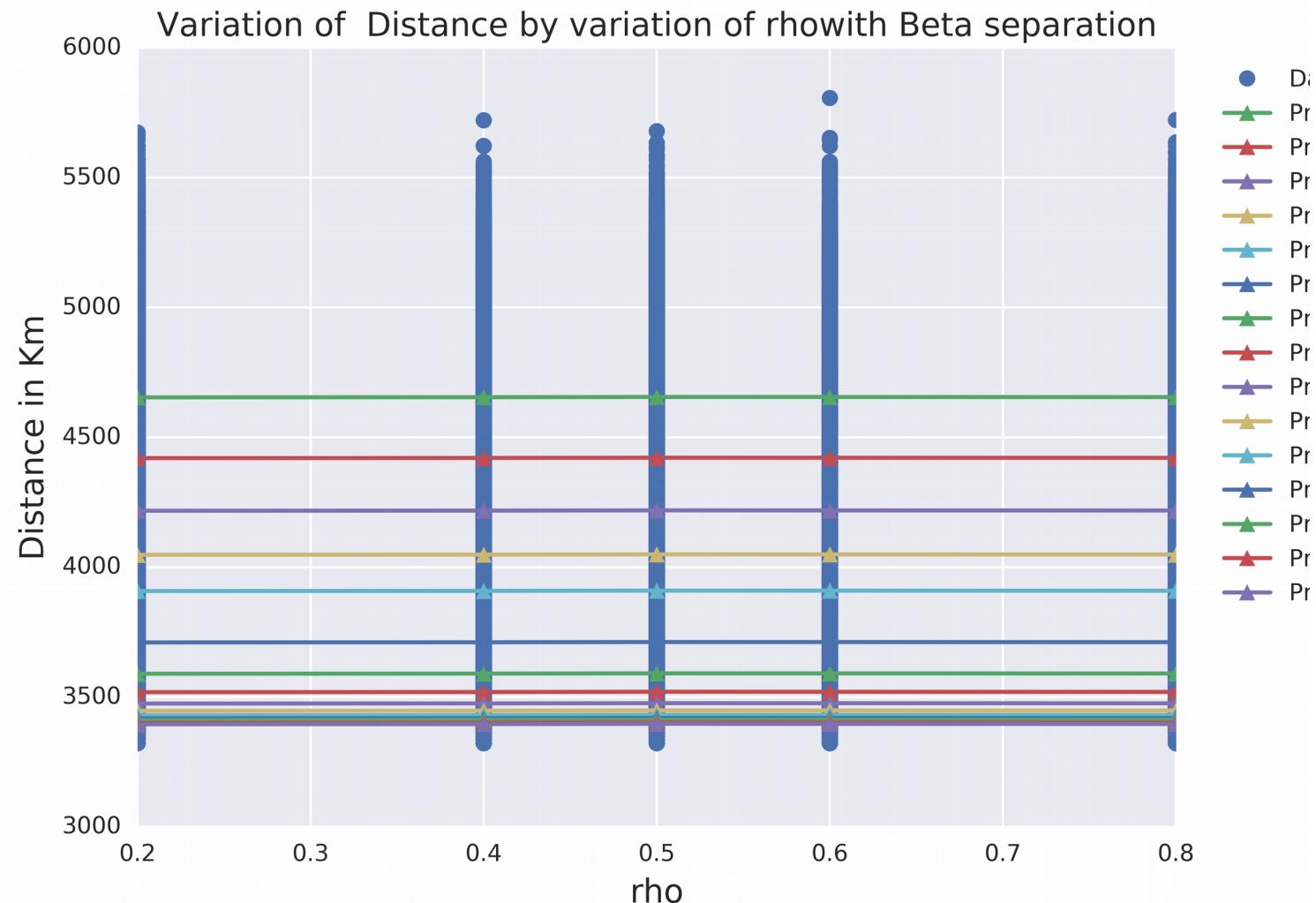
Statistical Analysis - Category Model

Parameter	R ² - Linear	% - Linear	R ² - Cat	% - Cat	Pearson Corr	Spearman Corr
Alpha	0.00005	0.00	0.0042	0.42	0.0070	0.0160
Beta	0.5713	57.13	0.8292	82.92	-0.7559	-0.8566
Rho	0.000004	0.00	0.000004	0.00	-0.0020	-0.0019
Elite	0.000005	0.00	0.000005	0.00	-0.0021	-0.0022
Ant	0.0048	0.48	0.0048	0.48	-0.0696	-0.0756
Limit	0.0326	3.26	0.0327	3.27	-0.1808	-0.2291

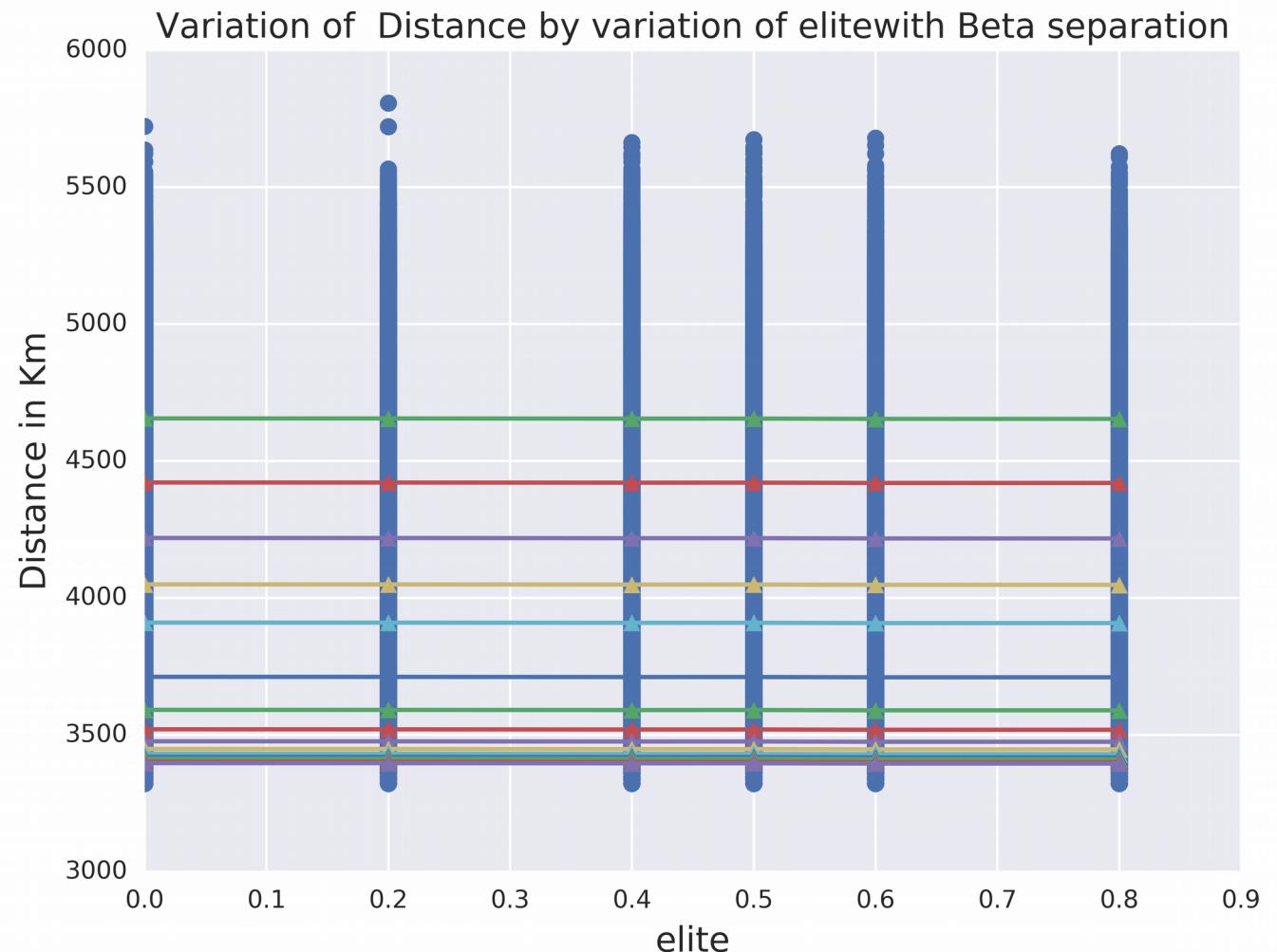
Statistical Analysis - Two Categories



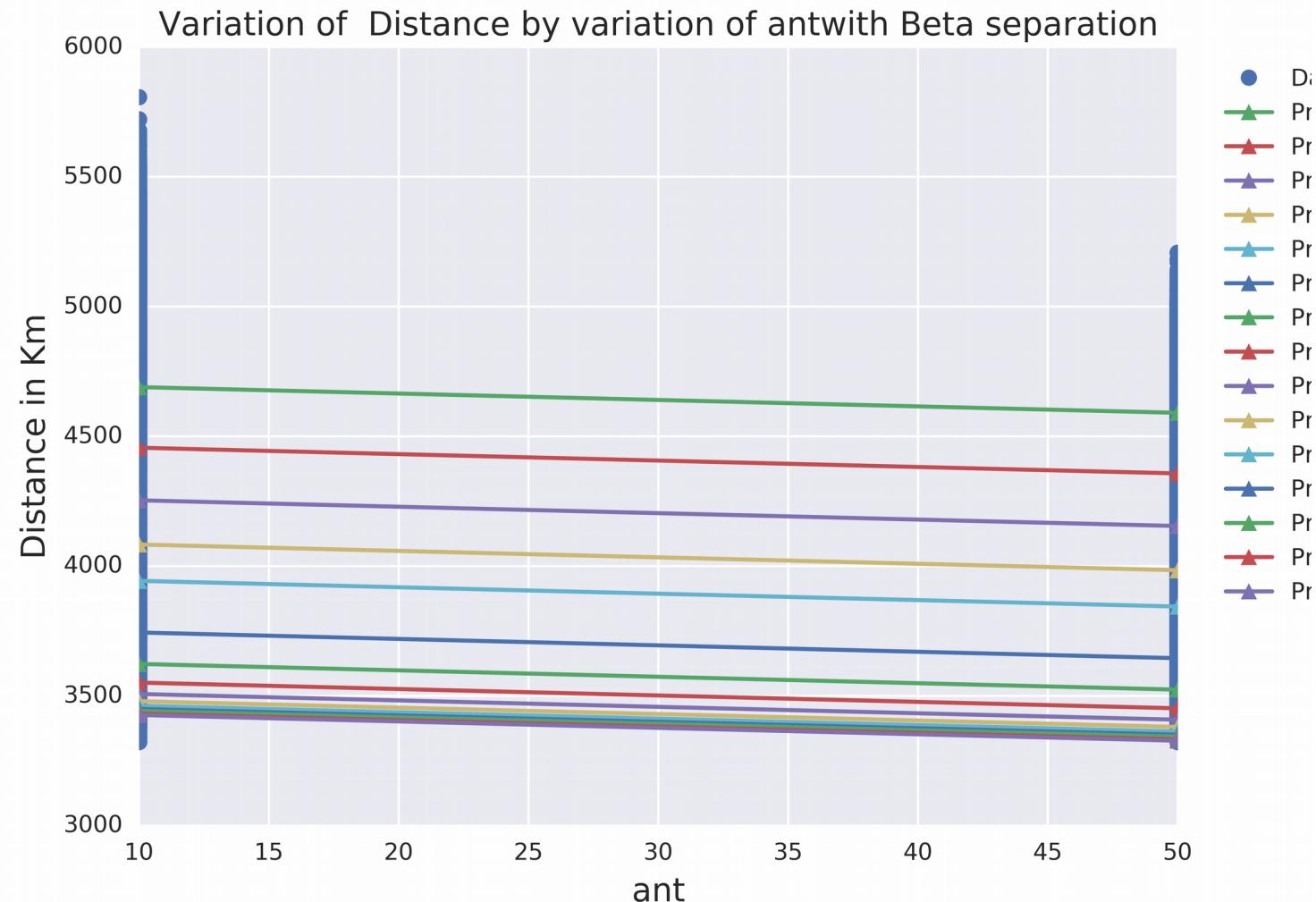
Statistical Analysis - Two Categories



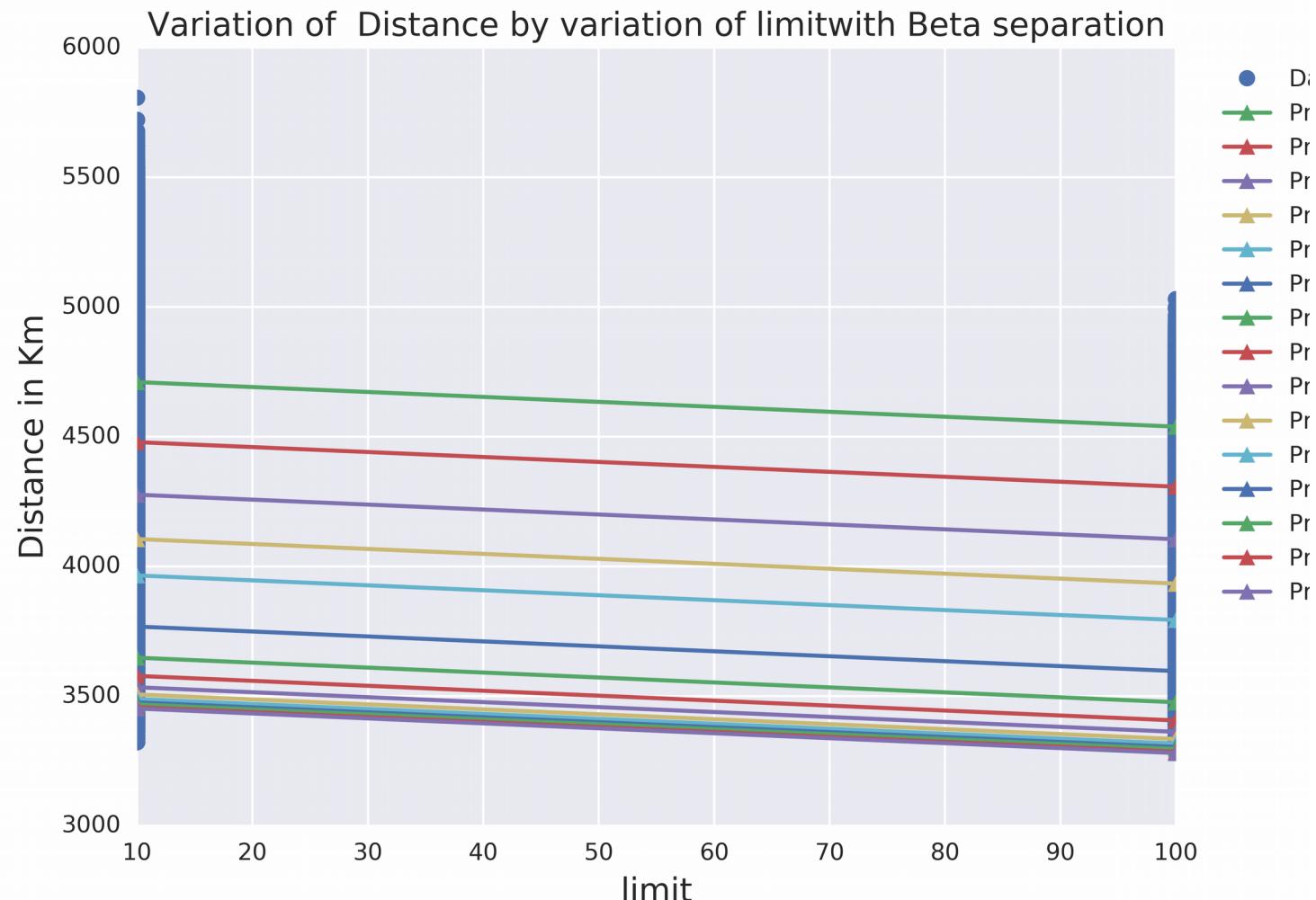
Statistical Analysis - Two Categories



Statistical Analysis - Two Categories



Statistical Analysis - Two Categories



Statistical Analysis - Two Categories

After this two analysis we reach the following conclusion to the parameters:

- Alpha: 0 or 7
- Beta: 7 (Higher)
- Rho: Anyone
- Elite: Anyone
- Ant: 50 (Higher)
- Limit: 100 (Higher)

Multi Category Models

Formula	R ² %	Diff Beta	Diff Previous
Distance ~ Beta + Limit + Ant + Alpha	89.03	6.11	0.01
Distance ~ Beta + Limit + Ant + Elite	89.02	6.10	0.00
Distance ~ Beta + Limit + Ant + Rho	89.02	6.10	0.00
Distance ~ Beta + Limit + Ant	89.02	6.10	2.86
Distance ~ Beta + Limit	86.15	3.23	2.17
Distance ~ Beta + Ant	83.99	1.06	1.06
Distance ~ Beta	82.92	0.0	0.0

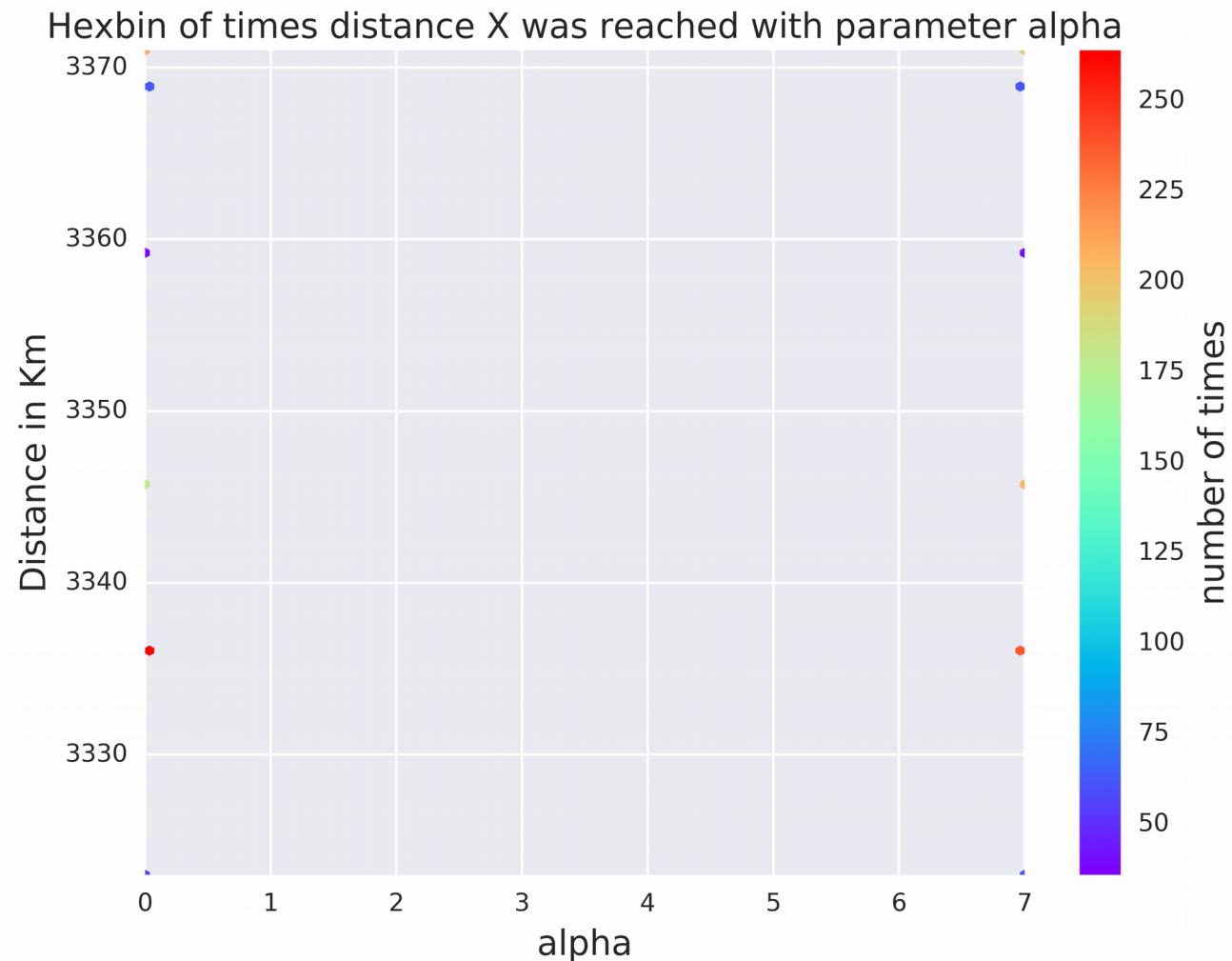
Based on this Test and the other results, we can see that:
Beta, Limit and Ant holds the explanation of the Model
Rho, Elite and Alpha are not statistical Relevant

New Simulation

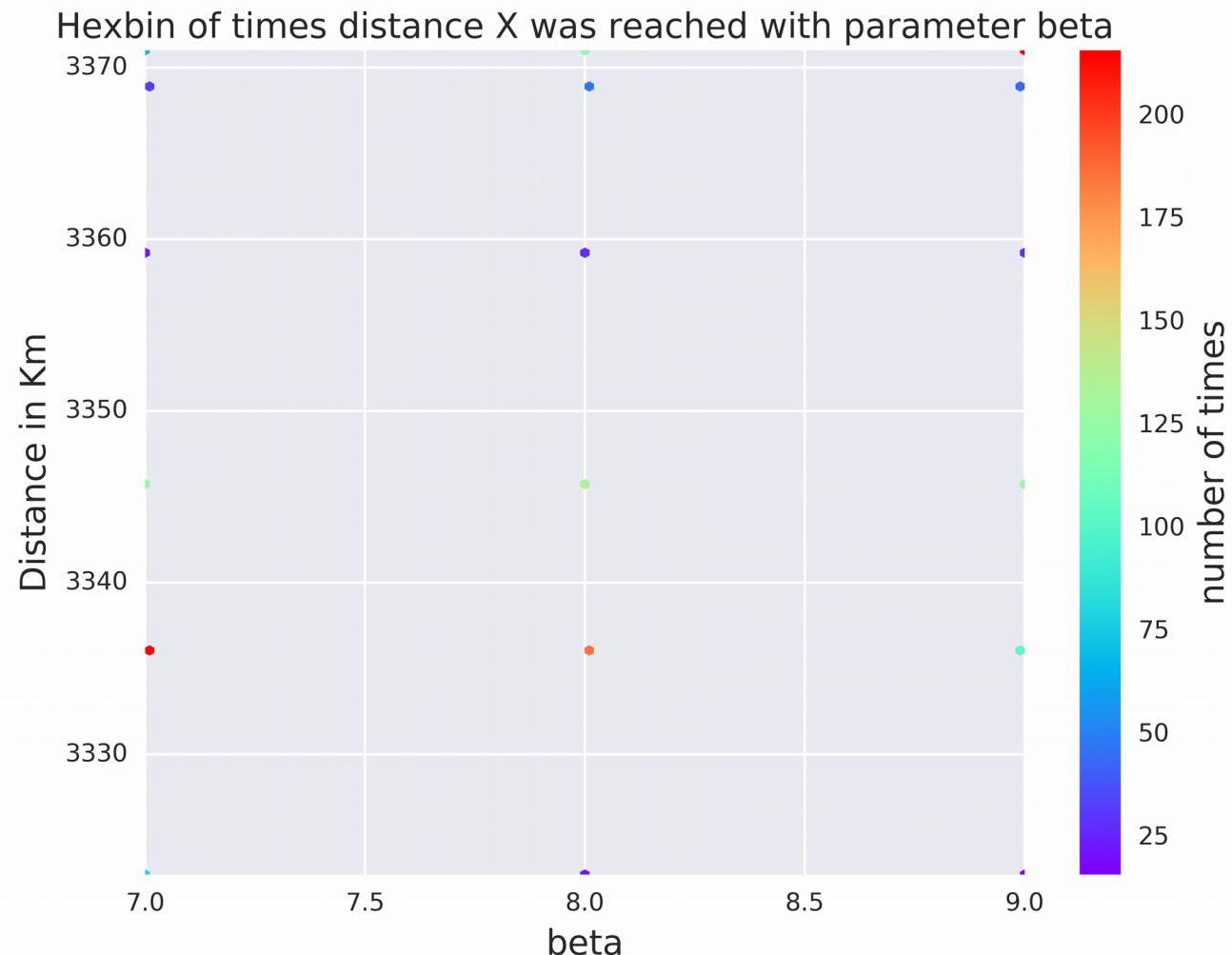
To confirm the results found, I generated a new set of data with the following parameters:

- Alpha: 0 and 7
- Beta: 7,8 and 9
- Ant: 50, 100, 200
- Limit: 100,500,1000
- Rho: 0.8
- Elite: 0.6

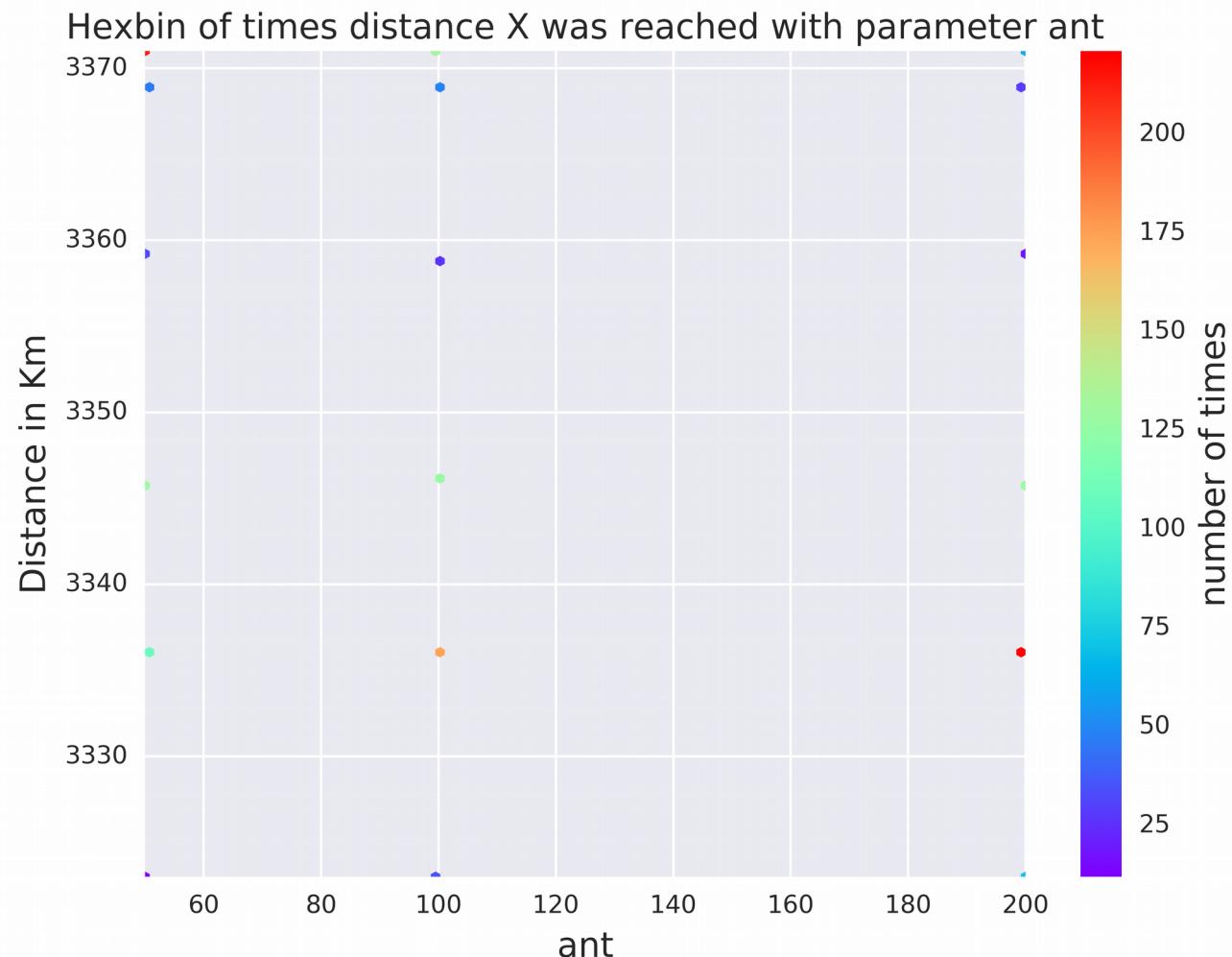
Hexagram



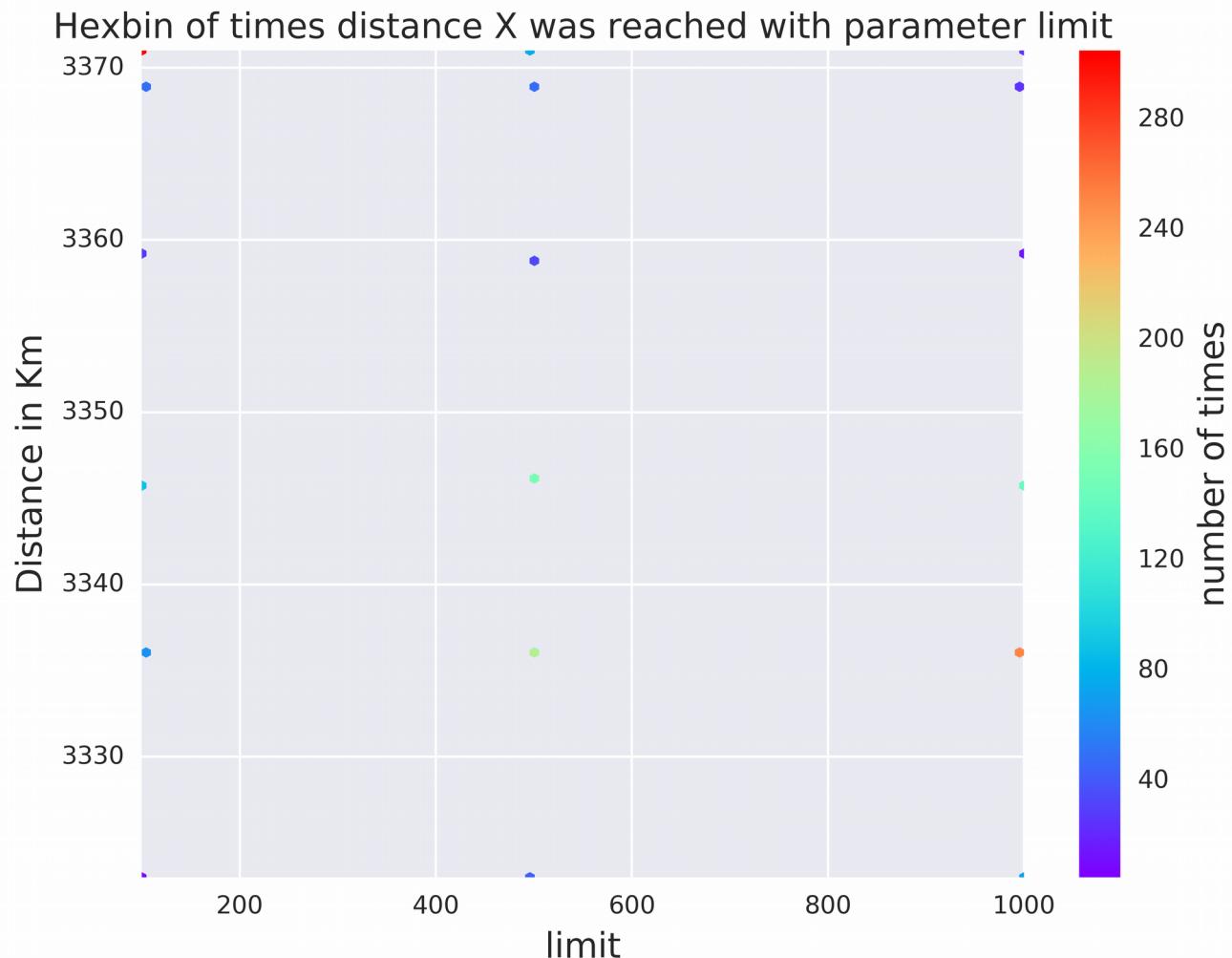
Hexagram



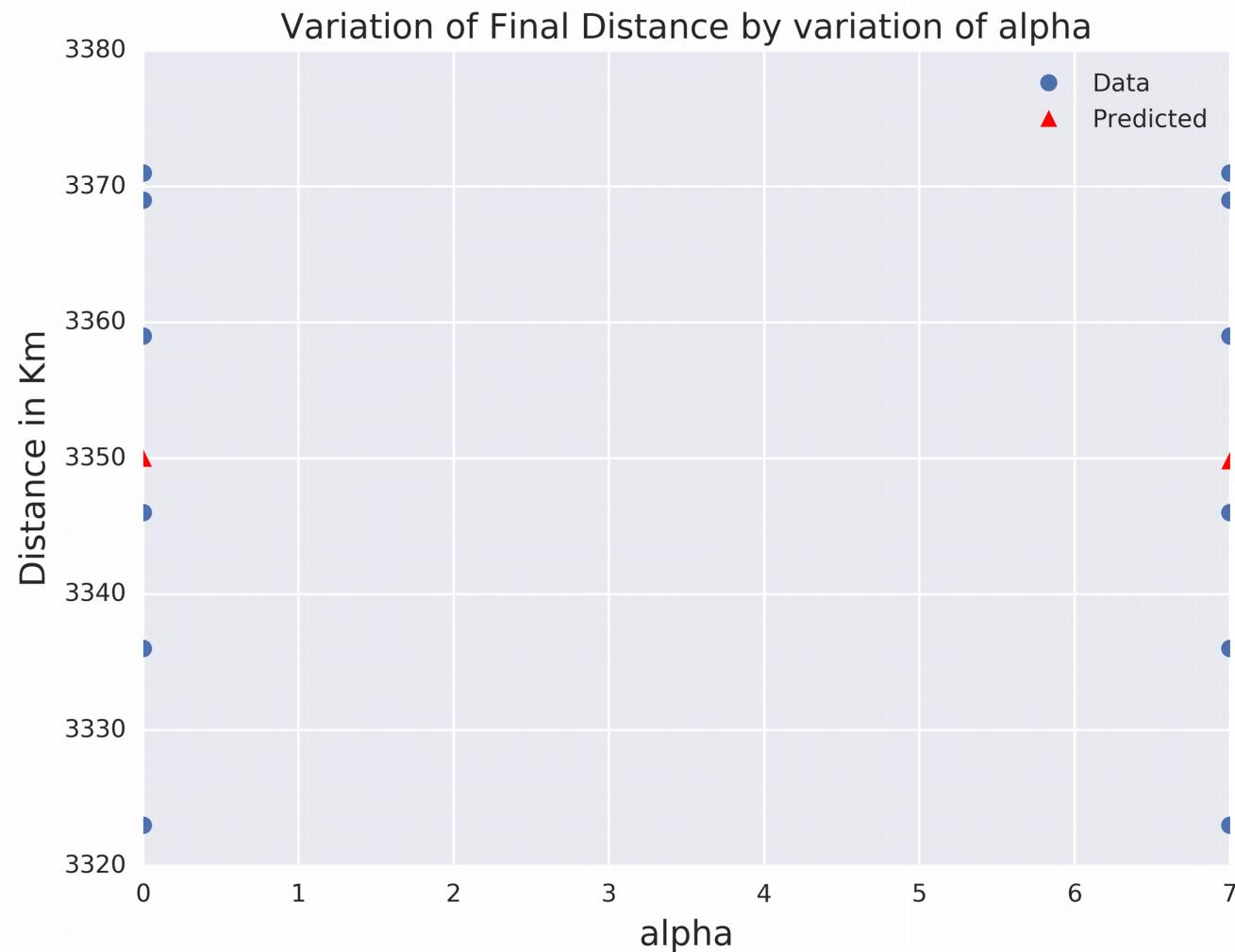
Hexagram



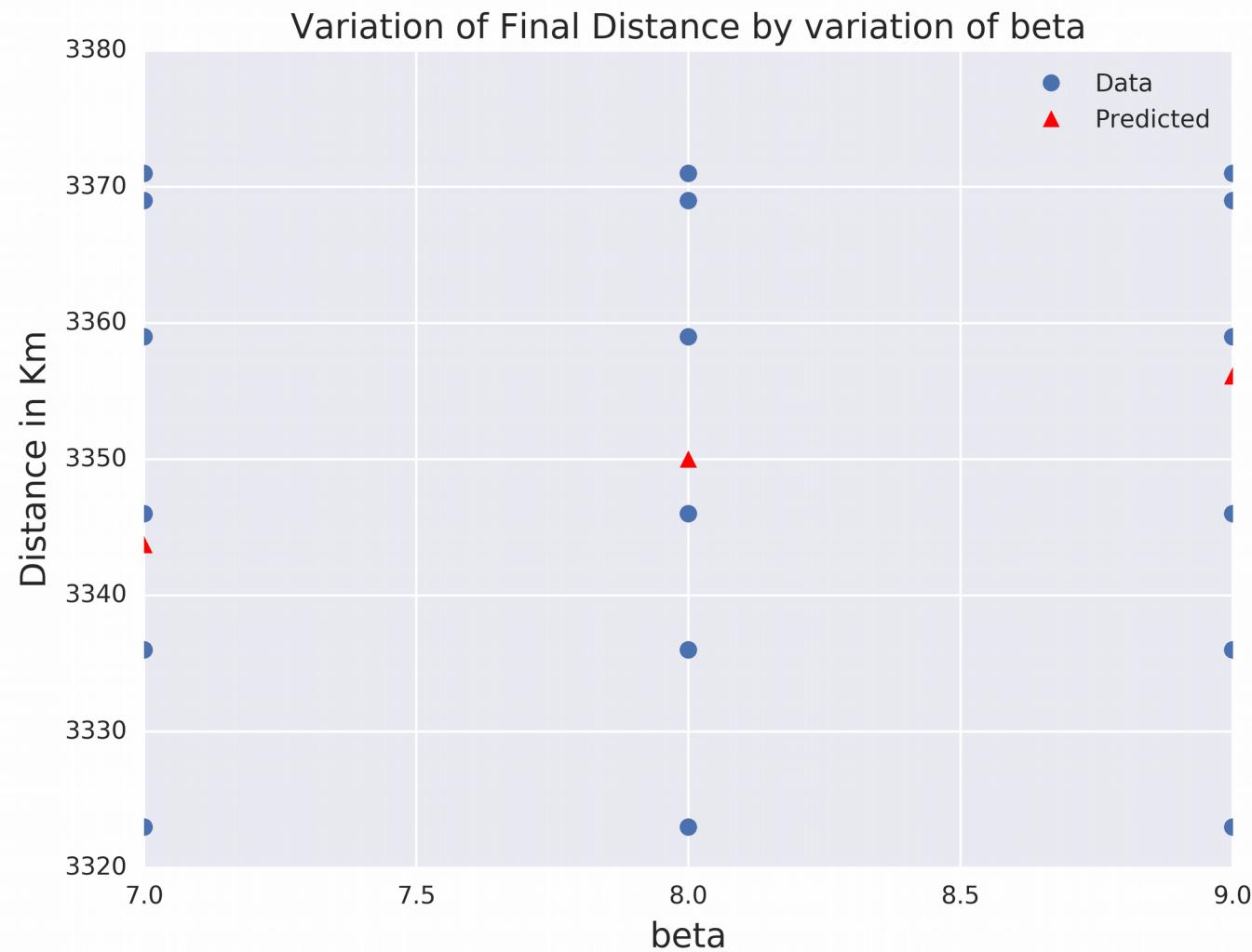
Hexagram



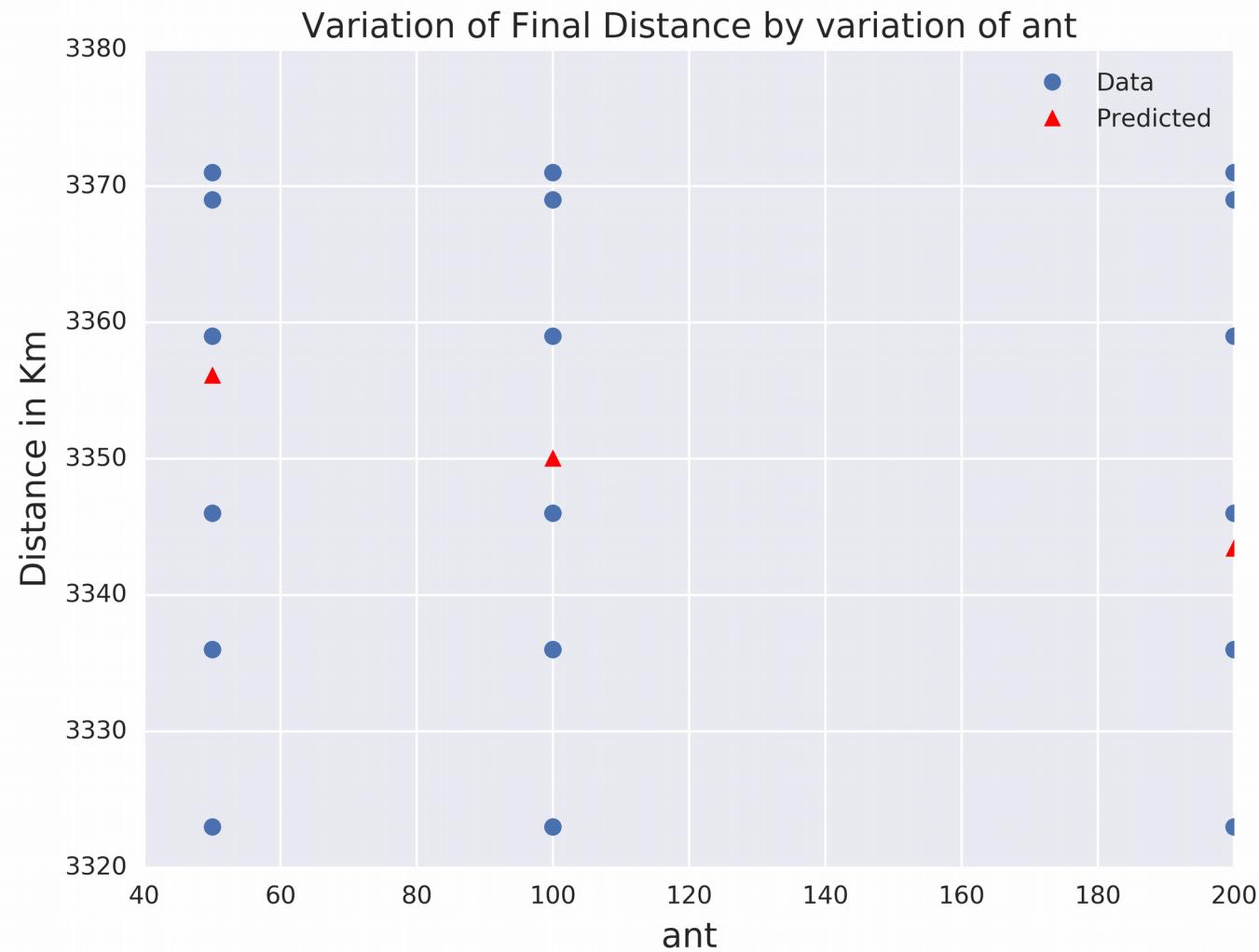
One Category Model



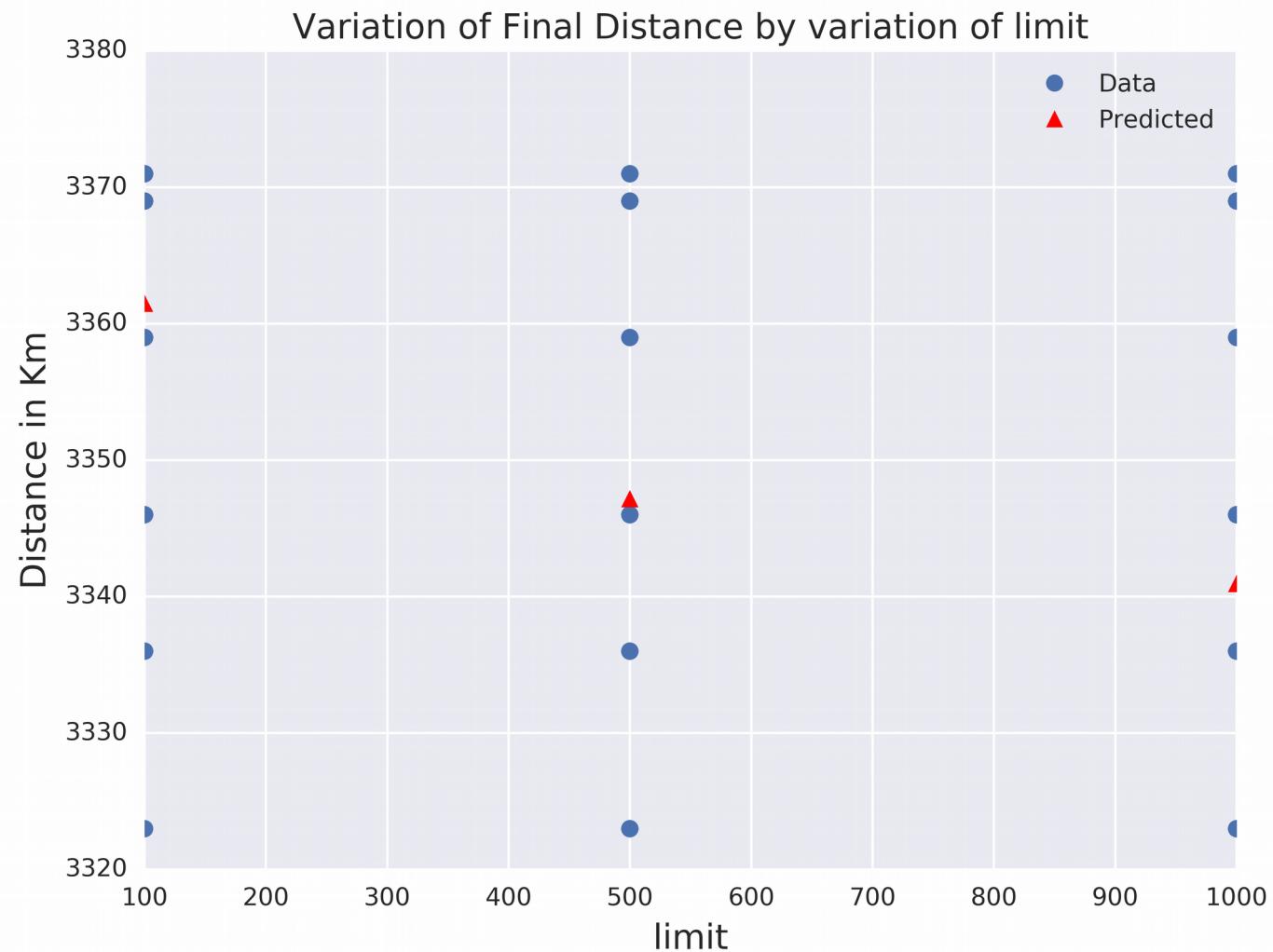
One Category Model



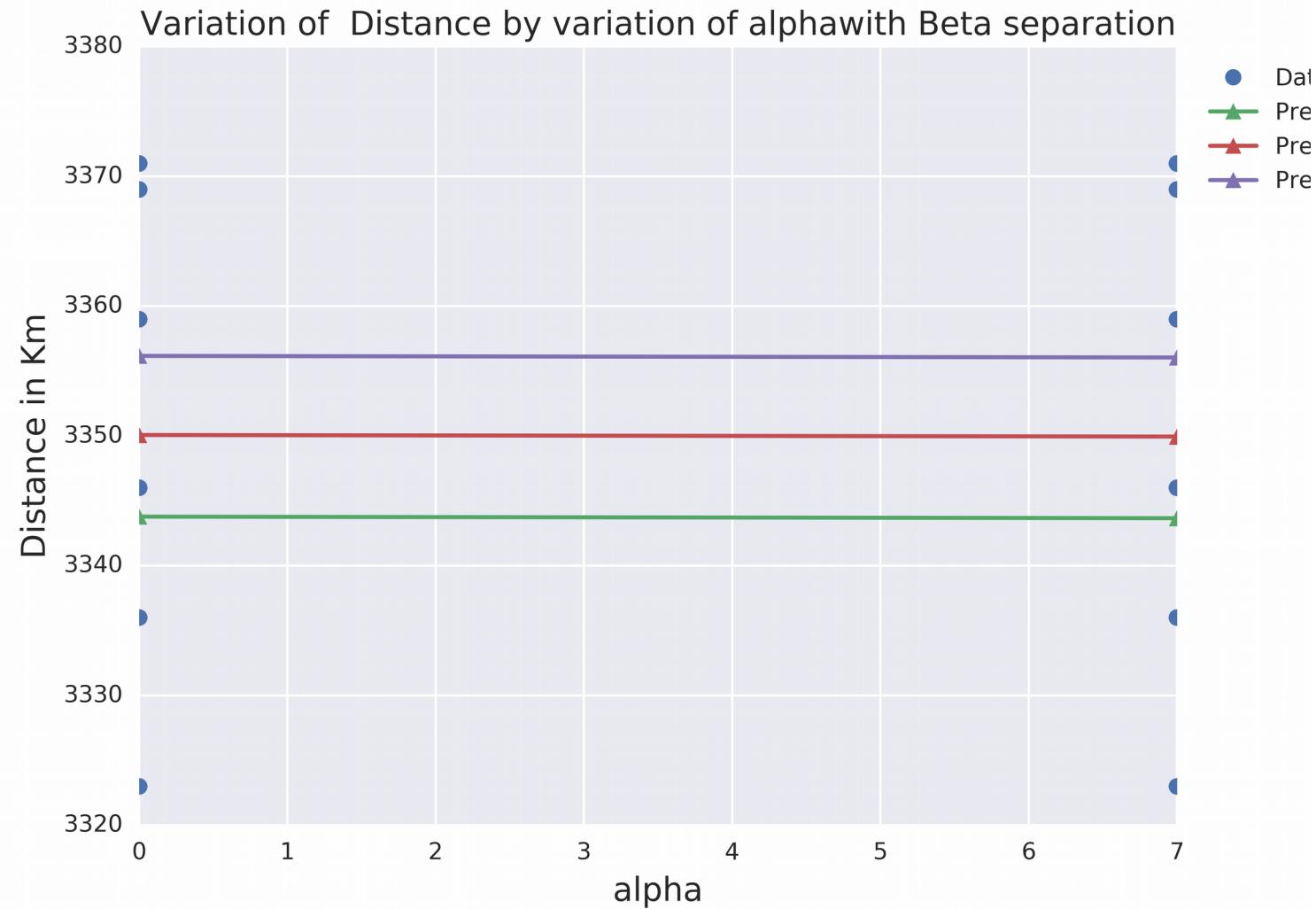
One Category Model



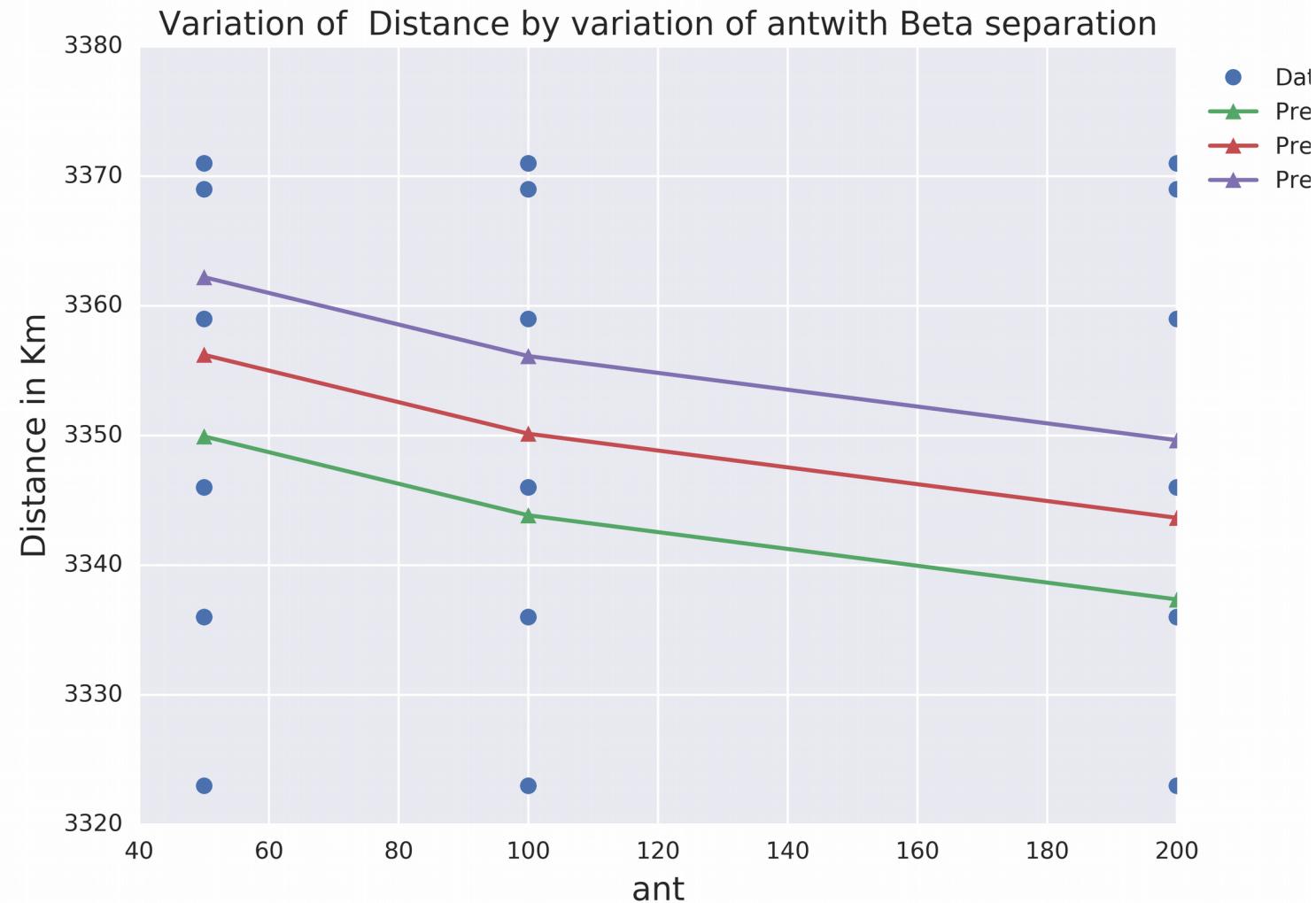
One Category Model



Two Categories Model



Two Categories Model



Final Model Data

OLS Regression Results

Dep. Variable:	distance	R-squared:	0.481		
Model:	OLS	Adj. R-squared:	0.479		
Method:	Least Squares	F-statistic:	248.0		
Date:	Mon, 08 Feb 2016	Prob (F-statistic):	1.99e-224		
Time:	09:25:39	Log-Likelihood:	-6240.7		
No. Observations:	1611	AIC:	1.250e+04		
Df Residuals:	1604	BIC:	1.253e+04		
Df Model:	6				
Covariance Type:	nonrobust				
	coef	std err	t	P> t	[95.0% Conf. Int.]
C(beta)[7.0]	3361.6146	0.768	4374.767	0.000	3360.107 3363.122
C(beta)[8.0]	3367.9053	0.768	4382.954	0.000	3366.398 3369.413
C(beta)[9.0]	3373.7408	0.767	4395.979	0.000	3372.236 3375.246
C(limit)[T.500.0]	-14.3315	0.710	-20.178	0.000	-15.725 -12.938
C(limit)[T.1000.0]	-20.5515	0.713	-28.812	0.000	-21.951 -19.152
C(ant)[T.100.0]	-6.0852	0.710	-8.568	0.000	-7.478 -4.692
C(ant)[T.200.0]	-12.7256	0.713	-17.840	0.000	-14.125 -11.326
Omnibus:	6.119	Durbin-Watson:	2.004		
Prob(Omnibus):	0.047	Jarque-Bera (JB):	6.121		
Skew:	-0.135	Prob(JB):	0.0469		
Kurtosis:	2.864	Cond. No.	4.38		

Further Work

This work generated a sequential Methodology to generate the graphs and statistical test to analyze a dataset with Ant Colony System

Run other instances through this Methodology

Different instances with similar Size – holds on other graphs

Different instances with bigger size – holds on bigger graphs

Run a Neural Network to see an automatic answer for the parameters.

Thank you!