

## How High Will My Magikarp Jump?

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### ABSTRACT

The Pokémon Company's new mobile game, Magikarp Jump, has simple game play where the goal is to train your Magikarp to jump as high as possible. The distance jumped (in meters) is solely determined by the jump points possessed by the Magikarp, which can be earned by eating berries and by training your Magikarp. Measurements for jump points are imprecise and only recorded with three significant digits, and the relationship between the two is not defined by the game.

What is the relationship between height jumped and jump points, and how does one deal with potential bias from imprecise measurement? Using data obtained by the presenters and their children through several dozen playthroughs, this presentation explores techniques used in estimation and the importance of statistical graphs for exploring the data and assessing quality of fit.

### INTRODUCTION

This E-Poster grew out of simple curiosity. One of the authors had been playing a mobile game with his children called Magikarp Jump by the Pokemon Company. The goal of the game is to get your Magikarp to jump as high as possible. Via training, they accumulate jump points and there was a clear relationship between jump points and feet jumped, and there was no random component. A certain number of jump points always yielded the same feet jumped. We set to work to determine the mathematical relationship that existed between the two.

SAS® statistical PROCS contain very helpful plots that allowed us to assess our models very quickly and easily. All plots here, with the exception of the initial scatter plot are either standalone plots that are generated by the PROC selected or are 'cut' from a bigger panel of diagnostic plots.

### SO CLOSE, YET SO FAR

The first thing we did was to plot the relationship between jump points and feet with PROC SGPLOT. The relationship clearly appeared to be exponential.

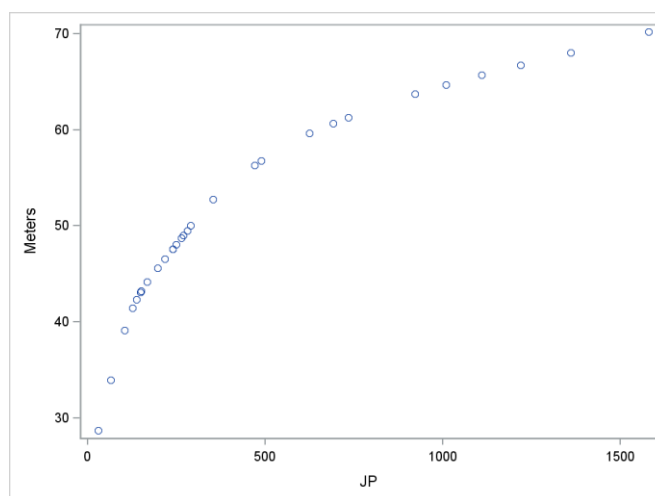
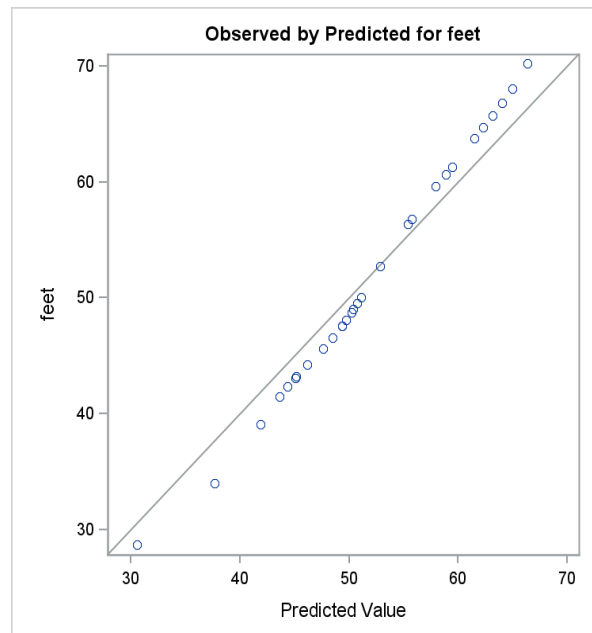


Figure 1. Scatter plot of relationship between jump points and feet.

We logged JP and ran a zero-intercept linear regression using PROC REG. The  $R^2$  statistic was 0.9986 which basically suggested a perfect fit. One important point was that, at the time the game was initially launched, measurements of feet jumped were imprecise and only recorded to three significant digits, which presumably accounted for the stellar but less than perfect fit suggested by the  $R^2$  statistic. However, examining the diagnostic plots from PROC REG suggested that we still had some work left to do. We were consistently predicting too large of a value up until about 55 feet jumped and then we were consistently predicting too small of a value after that point.



**Figure 2. Observed vs. Predicted for linear model with the log of jump points as the predictor.**

At this point there were three possible solutions. We could try some combination of:

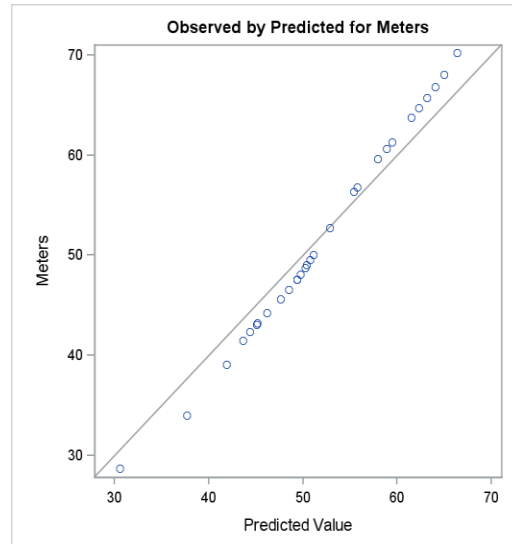
- Drop the imprecise measurements, refit and see how it looked to see if imprecision might be skewing the result
- Try a different model
- Look for additional predictors

We will proceed through these in order.

## **SOLVING THE PROBLEM**

### **SOLUTION 1: PRECISE MEASUREMENTS ONLY**

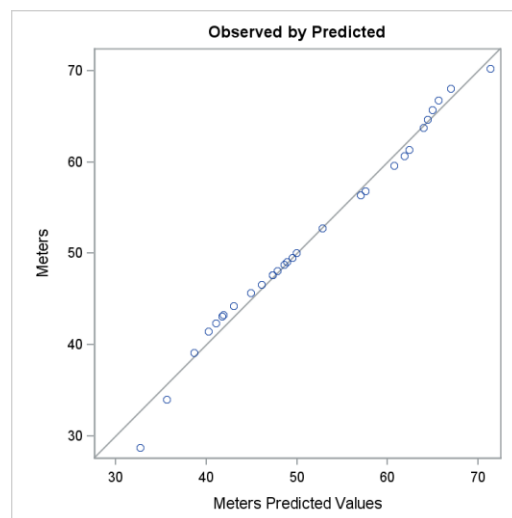
The first attempt was to drop the imprecise measurements and refit the data using PROC REG. I strongly suspected that there was a systematic bias in the imprecise measurements (e.g., always rounding up). However, upon fitting that data it was quickly apparent that this wasn't the problem as we saw the same exact pattern in the relationship between observed and predicted that we saw in the larger dataset.



**Figure 3. Observed vs. Predicted for linear model with the log of jump points as the predictor on precise data only.**

## **SOLUTION 2: A SPLINE**

Since the structure in the residuals did not appear to be driven by imprecision we knew that the exponential relationship that was apparent in the original scatter plot was not the underlying mechanism. This lead us to try a spline to see if we could determine an underlying basis, either linear or polynomial, using PROC TRANSREG. Polynomial basis did not improve over the linear basis, so a linear basis of four spline functions was selected for simplicity. While it was an improvement over the previous model, it still demonstrated clear structure.

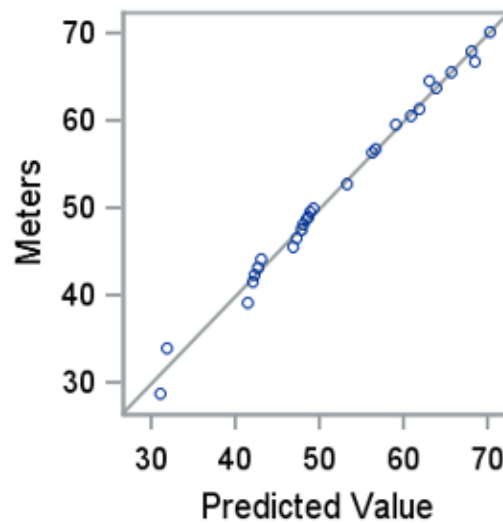


**Figure 4. Observed vs. Predicted for spline with the jump points as the predictor.**

## **SOLUTION 3: AN ADDITIONAL PREDICTOR**

We did some additional research on the game and found another potential predictor, 'level' which is a status that increments at specific intervals as your jump points increase. We used PROC GLM with an identity link, added level as a CLASS variable, and fit a linear model with untransformed jump points. This

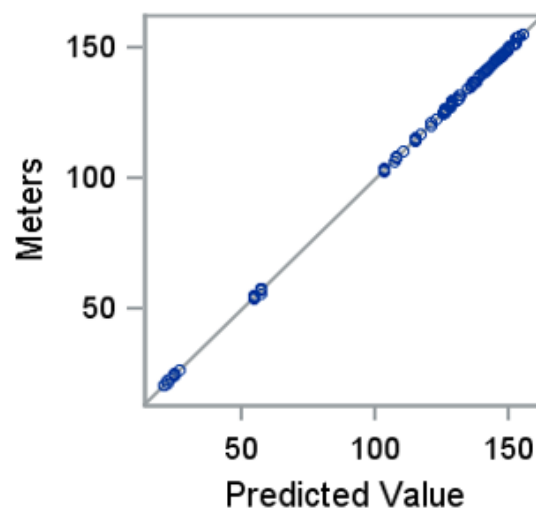
represented a slight improvement over the spline model, though it is not definitively better. While there were similar amounts of structure in the middle of the band, at the tails this model looked better.



**Figure 5. Observed vs. Predicted for linear model with jump points and level as the predictors.**

### WHAT WAS THE RIGHT ANSWER?

Fortunately, the game developers later started providing jump points with full precision. This definitively proved that the last model, the linear model with jump points and level as predictors, was the correct model. In essence, we had a model with a constant slope, but varying intercepts depending on the model. Our  $R^2$  statistic was 0.9999 and the graph below shows a perfect fit.



**Figure 6. Observed vs. Predicted for linear model with jump points and level as the predictors with precise measurements.**

### CONCLUSION

There are two major takeaways from this fun little project. First, we were reminded of the old adages that everyone learns in their introductory courses on regression: always examine your residuals, and plots are

your friend. We need to find a way for our models to account for as much structure as possible in the residuals, even if this means hunting down additional data. The other is that SAS provides very helpful diagnostic plots with many of their statistical PROCs - use them!

## CONTACT INFORMATION

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