China’s Wild Pandas: Nature Reserves For Panda Conservation

1. Introduction

After spending 30 years on the “endangered” list, China’s wild pandas have risen in numbers. Due to population rise, panda nature reserves have grown from 40 to 67 since last surveyed. Traditional methods such as supporting the construction of roads and railroads, mining, deforestation, and poaching have steadied to a decline, increasing the population. Legal protection and conservation efforts to protect habitations and forest farms were implemented by the Chinese government which was effectively introduced to lower extinction rates. Just in the last decade, giant panda populations have increased by almost 17%. The number of giant pandas globally has increased from 1,596 to 1,867 just from when they were last surveyed in 2003.

I chose this topic due to the recent news about the increase in the number of pandas. I have always loved pandas from a young age, and my interest in these furry friends cause me to wonder how abundantly they will continue to grow in the future. I decided to model exponential graphs to show the fluctuated population of wild pandas, along with the increase of wild pandas in the next 25, 50, 75 and 100 years to primarily show how improved wildlife conservation can help the increase of endangered species and prevent the extinction of animals essential to our world.

2.2 Census data

A problem I encountered while trying to research the panda population is it was very difficult to collect population records. I wondered if there was a way, I could collect credible sources showcasing panda populations. The solution I came up with was to compile research from multiple magazines and articles presenting population from the Official National Survey census from China. With this information, I created a data set as shown in Table 1 below.

- Statistics of each Official National Survey
- Official National Survey / Average Panda Population
- First National Survey (1971) / 1,075
- Second National Survey (1987) / 1,120
- Third National Survey (2003) / 1,596
- Fourth National Survey (2019) / 1,867

2.3 But what is an exponential equation?

An 'exponential' is defined as an expression or equation in which a variable, for example, 'x' occurs as the exponent of the base.

An example of a basic equation is .

As you can see, the variable ‘x’ and ‘y’ is placed next to its respective coefficient, so when it is expanded, is ‘2 multiplied by ’ and is ‘6 multiplied by ’.

An exponential equation can be presented as shown in this example.

In this variable ‘x’ is shown as a power of its base which is 4. So if the exponential was to be expanded, it would be times until it equals 64. An exponential equation can be used in real-life situations such as to model populations, carbon date artifacts, for investments and to help determine the time of death.

3. First method: Standard exponential structure

The first method involves using a ‘standard’ exponential formula to try and model an equation. This equation is written as

Where ‘a’ is the initial value or y-intercept, ‘b’ is the constant average change factor, and ‘x’ is any real number. I changed the exponent ‘x’ to ‘t’ to represent time intervals since this is what models population growth.

My initial reaction to this equation was that it seemed ‘too easy’ to get an exponential that was accurate enough to model the population.

The initial value ‘a’ was ‘1075’. However, there was an issue in which didn’t know how to figure out the constant change. After some thought, it occurred to me that the constant ‘change’ was the same as a constant ‘ratio’ To achieve this ratio I decided to divide the 2nd value by the 1st value, to get a constant of 1.04186.

b =

? 1.042

However, I realized I needed to change the initial value to ‘1867’ because the future populations are being measured from the current time period.

Therefore, the formula was

For example, if the equation was to show the population of pandas after 25 years, the variable ‘t’ would be substituted for ‘25’.

pandas

The value is rounded down because it is estimating population growth and it isn’t possible to have less than a whole of a panda. Using this method, I created a data set as shown in table 2 by substituting each of the time intervals of 25,50,75, and 100 into ‘t’.

Future panda populations (1st Method)

Year

Estimated population of pandas

2019

1867

2044

5222

2069

14605

2094

40852

2119

114265Table 2: Estimated panda populations using the first method.

Figure 1: Using the first method didn’t yield a good r-squared value, along with misplaced points that didn’t fit the graph.

As it is shown in figure 1 above, the points are not fitting the graph properly. The r-squared value, also called the coefficient of determination, is a measure of how close the plotted points are to the regression line. In most cases, the closer to the number '1' the value is, the better fitting the points are within the graph. However, in this case, the r-squared value is 0.6772 which is not ideal if we need the graph to display the values as accurately as possible, as close to the graph as it can be.

So even though the first method wasn’t accurate like I assumed it to be, it made me understand how the can play a big part in conveying how accurate points are placed near or on an exponential model, and it was like a ‘practice’ to me on how to plot exponentials on graphs.

Although this method was easy, I think creating an average constant value could improve both the r-squared value and the composition of how the points fit on the graph. This made me think about whether using different x and y values would assist in a more ideal r-square value and better-fitting points on the graph.

4. Second method: Standard exponential structure

Similar to the first method, I used the standard exponential structure

However, instead of just using one point to figure out the value of constant ‘b’, I did the same process in finding b values by dividing the adjacent values, and these values as shown in table 3 were averaged to find the constant ratio ‘b’, which was approximately 1.21 on average.

Table 3: The three values on the very right were averaged.

To use this equation to find the future value, however, just like the first method the initial value must be changed from '1075' to '1867', so the final equation was

x

Then I attempted to create a data set similar to table 2 in the first method by substituting time intervals for ‘t’ and placed it into a graph as shown below in table 4.

Future panda populations (2nd Method)Table 4: Estimated panda populations using the second method.

Year

Estimated populations of pandas

2019

1867

2044

6782

2069

17389

2094

45293

2119

298482

In comparison to the data in table 4 below, it does show a significant increase in the population. As shown in figure 2, some of the points still didn’t match up the way it should have. The r-squared value was 0.8293, which is much better but still not the value I was hoping to get. When compared to the first method, I think this method is more time consuming, but it gives you a better r-squared value even if it isn’t entirely ideal. I felt it was more likely to make mistakes in this method as opposed to the first method. However, this method did help me understand the importance and comparison between the accuracy of results when averaging values instead of just using one value immediately. So then I thought perhaps using natural logarithms can give a more precise exponential function.

Figure 2: There was a better r-squared value, but it still wasn’t ideal, and not all the points fit well enough on the graph.

5. Third method: Natural logarithm

The third method is a little bit different, and before attempting this method I was very confused about how to find an equation from it. Using natural logarithms wasn't my strong point however I still decided to try it out to see what kind of result I had.

The first step in this method was to start with the standard exponential formula:

If a natural logarithm was used, however, the above equation would look like this:

Using the laws of exponentials, ‘ is in the and can be expanded into , into

The law of logarithms states that if there is a power above the logarithm in the form , it can be rearranged in the form . So the expression can be rearranged as

This is the same form as the linear equation

Therefore, I assumed that ‘m’ equals ‘lnb’, and that ‘c’ y-intercept equals ‘lna’.

I realized I needed to have points to be able to evaluate m and c. So I briefly found the points using ‘x’ and instead of using ‘y’ I used the ‘lny’ (ln) value as shown in figure 3 below.

When x = 0, ln= 7.5320881, the y-intercept ‘c’ (lna) is around 7.53 because that’s where it hits the y-axis.

Figure 3: To the left, there is a table of points using ln(as the y value.

To find ‘m’ I used the formula to substitute any 2 points, I chose to substitute (0,7.5320881) and (4, 12.606465).

If the ‘m’ value of approximately 1.27 and the y-intercept ‘c’ value were substituted into ’, the final liner equation would look like this:

x+

So if the y-intercept value ‘c’ is ‘lna’, the value of ‘a’ would be found by using the natural logarithm to rearrange it into an exponential that equals ‘a’.

And if gradient value ‘m’ is ‘lnb’, the same process above would be used to find the value of ‘b’.

Once ‘a’ and ‘b’ were found then these values would be substituted into the exponential formula.

This equation is slightly different than the 2 equations from the previous methods, so I was sceptical about whether it would yield an accurate graph fit and a better r-squared value.

Figure 4: The third method gave the lowest r-squared value so far, with barely any points fitting

on the graph.

As shown in figure 4, it gave me the lowest r-squared value of 0.3058. I think this was because the graph itself was further away from the positive side, and resided mostly within the negative side as compared to the other functions in the first and second method. This made it safe for me to assume that the points did not fit on the graph as they were on the positive side and didn't fit as closely as they did in the second method. This made me wonder whether I was able to use a better formula besides just the standard formula.

4. Fourth Method: Exponential growth formula

I tried to use a harder method using the exponential growth formula. This is given in the form of the formula

Which I had learned in class to use to construct and identify growth on graphs. In this equation 'y' is the future value, ' is the initial value, 'r' is the rate of growth as a percentage, and 't' is the time intervals that have passed.

For example, a specific type of bacteria can double in just 15 minutes. At 10 am there are 1000 bacteria in the sample. How many bacteria will be present at 12 pm?

So, 'a' will be 1000 because that is the initial value. The constant 'r' will be 100% as the population is doubling.

Lastly, 't' is 2 since the growth is being calculated from 10 am to 12 pm, in 2 hours.

x 4

4000 bacterium were present at 12pm.

This same process was used to find the population model equation.

The initial value 'a' is 1075 so it can be substituted into 'a'.

At this point, a problem I experienced when trying to construct this formula is that I didn't know the current rate of growth. However, I found a formula that I could use to evaluate it.

For example, the population of '1120' and the value above it '1075' were substituted as 'present' and ' past' values respectively.

Lastly, the number of years between 1987 and 1971 was 16, which was substituted into 'n'.

This was simplified to get a growth rate of approximately 0.00256 to 3 significant figures or approximately 0.256%.

From the second method, I recalled that finding an average can help get a more accurate value, so on excel, I used the method above for each of the populations, and then averaged it to find the mean constant as shown in table 5 below.

Table 5: Similar to the second method, the results were averaged to get a more precise value.

If the growth rate is reduced to 3 significant figures and substituted into ‘r’, then the formula would be

Further simplified, the final formula is

I wasn’t sure if this was correct, and just to make sure I decided to use the ‘guess and check’ method to test.

I decided to substitute ‘48’ into ‘t’ years to see if it resulted in 1867 pandas.

? 1867.02

But since it isn’t possible to have “0.02 of a panda”, the value is rounded down to 1867.

The initial value of “1867' must be used as the population of pandas in the future starts from the present time period. So, instead of '1075' as the initial value as it was previously discussed, it would be changed to '1867’

So the formula will look like this:

The time in years is represented by ‘t’.

To show consistent time intervals, the periods of increasing by 25 will be used (0, 25, 50, 75, 100…). This means one must substitute each of these into the equation. For example, using this equation one could find the population of pandas as shown below.

Firstly 25 years would be substituted as a ‘t’ value.

? 2489 pandas

However, this value needs to be rounded down as it isn't possible to have 0.1029th of a panda, thus resulting in an estimated population of 2489 giant pandas 25 years from 2019 onwards.

I continued to use this process to find values for population numbers 50, 75 and 100 years in the future and placed them in a table (table 6).

Future panda populations (4th method)

Year

Estimated populations of pandas

2019

1867

2044

2489

2069

3318

2094

4424

2119

5898

Table 6: Estimated panda populations in the future based on the National Survey results.

Firstly I started by creating a table on Desmos and adding the x value which was the number of years and the y value which was the population of the pandas. Then I added the exponential function by adding the equation into the grid.

The points from table 6 fit the graph almost perfectly. They were plotted almost directly on the function, with an r-squared value of 0.9805 which is very close to an “ideal” perfect relationship of 1.

Figure 5: When compared to the exponential function plotted on the graph, the points almost fit straight on the graph.

In comparison to the other 3 methods, this method wasn’t the easiest and quickest way to get a perfectly plotted graph, but the final r-squared value was higher than all the other 3 results and all the points seemed to fit into the exponential graph very nicely, with no significantly high or low spots.

6. Conclusion

In conclusion, the aim was to model exponential graphs showing the initial increase of pandas and the significance of consistent wildlife conservation to show how panda populations will develop over time. Constructing an exponential equation from the current Official National Surveys of panda populations helped estimate increasing populations in the next 25, 50, 75 and 100 years. All the methods of producing estimate population numbers showed a significant increase in pandas, however the best method was the 4th one after using the growth rate exponential formula. There were limitations in terms of finding appropriate data, creating visually accurate models and finding an exponential equation that can determine an accurate population growth using the pre-existing data. To extend this exploration, I would like to create logistic models of these methods and compare them to see how they display the values differently.

7. Bibliography

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