AL- Rafidain University College

PISSN: (1681-6870); EISSN: (2790-2293)
Journal of AL-Rafidain University College for Sciences

Available online at: https://www.jrucs.iq

JRUCS
Journal of AL-Rafidain University College for Sciences

Multiple non-Linear Regression and its Applications

Dr. Abida A. Al-Taie
abida@ruc.edu.iq
Accounting Department - Al- Rafidain University College, Baghdad, Iraq

Article Information

Article History:
Received: January, 14, 2023
Accepted: March, 3, 2023
Available Online: December, 31, 2023

Keywords:
Regression, Multiple non-Linear, transformed values, model efficiency standard, parameters.

Correspondence:
Dr. Abida A. Al-Taie
abida@ruc.edu.iq

Abstract

The non-linear slope reflects the features of the parameters of the model to estimate the values of the approved variable, and the number of independent variables are two or more, the non-Linear model requires complex approximation operation in self non-Linear models, which cannot be converted into α sign by performing known conversions.

https://doi.org/10.55562/jrucs.v54i1.626

Introduction

If our focus was on statistical reasoning, with some attention to interpretation and decision making, because the decision to be taken after statistical reasoning usually depends on external considerations that are not available for statistics.

The business man who asks for a sample survey, he must benefit from the wisdom of his practical experiences in a report on any of the adopted to take the most appropriate to use it as approved results.

There are many decisions that statistics adopt to refer to the step to make a subsidized decision that has been accepted. The simplest of which vis only two cases that can occur and has two alternatives to the appropriate application. For example: the gardener, which may be appointed by the possibility of a severe frost that destroys his crop from some citrus fruits, and therefore he must decide whether this needs to protect his crop from frost. The two potential cases are: front, or not, as for the two possible aspects of each cases, they are: take protection precaution or not.

The most general pattern of this type of problem occurs when the number of cases can be occurred; 2≤ k, and the number of possible treatments towards these cases is: 2≤ 0.1. For example: A commercial institution may divide a new product into one of three groups, a producer who had successfully successful, average success, or a product that has not been successful. And testing the processors is one of the television advertisements, the announcement of the radio, the announcement of the newspapers or the advertisement of the distribution of bulletins and stickers: since the methods that we are dealing with do not depend on values: 1 and k, provide that each of them is more than one, so we will suffice here to study they simplest type of these problems where: 2=1 and 2=k.

1. The payoff table

We assume that is a financier of sports festivais, he cannot decide whether he must believe against the fall of the rain. If we assume that his net profit is :
20.000 \$ → if it is not rained, and : 2000 \$ → if it is rained.

And he will buy an initiative to secure its proceeds: 20.000\$ at a cost of : 5000\$. We will represent this information in a schedule: 2*2 is called the payment schedule: in which the net profit is clarified under the various possibilities, Table (1) explains this information as follows:

Table (1)

Weather condition	Action	
	Insurance:	No insurance
Clear rainy	15.000	20.000
	17.000	2.000

The rule on which one of the decisions will be preferred to be the expected profit. Therefore, the decision will only depend on whether the expected profit as a result of insurance is greater than the expected profit in the event that it is not purchased (insurance policy). To calculate these two expected profits, we assume that :
P: the possibility of the atmosphere on the day of the match, meaning that:
(1-p) : the possibility of rain on this day.

Referring to the definition of the expectation in the possibility distribution, the expectation in the possibility distributions, the expected profit account under these two procedure that we will symbolize with the symbols: E1 and En, will be as shown in table (2).

$$E1 = 15.000\ p + 17.000\ (1-p) \quad (1)$$

$$En = 20.000\ p + 2000(1-p) \quad (2)$$

Table (2)

Weather	probability	Insurance		No insurance	
		Profit	Expected profit	profit	Expected profit
Clear rainy	p	15.000	15.000p	20.000	20.000p
	(1-p)	17.000	17.000(1-p)	2.000	2.000(1-p)
∑	1		E1		En

We assume that the value: p: is unknown. Then: possible procedurals will be equal, assuming that : p : will achieve the resulting equation from : En = E1
So, p : the following equation must be achieved :
$15.000p + 17.000(1-p) = 20.000\ p + 2000(1-p)$.
To solve this equation, we find that : $p = 0.75$

The value of A; this which is given, is equal to the two values in this problem, is called the double turning point. It is clear that in the case : $p > 0.75$, the financier will not be believed, because: the more clear the weather, the less the need for insurance. In the case: $p = 0.75$; the procedures will be equal. This fact can be proven compulsory, by solving the varying : $En < E1$, as follows : $20.000p-2000(1-p) > 15.000p + 17.000(1-p)$.

Since we use the differences in the same way as using levels, except in the event of a negative number, this varying leads to :
$20\ p + 2(1-p) > 15\ p + 17\ (1-p)$
Or : $5p> 15\ (1-p)$
Or : $p > 15/20$

Here; the sports financier must consult the meteorological records for this period in which the sports festival will be held, to find out the percentage of the atmosphere in those days if it will exceed: 0.75 if this is done and it is ready to benefit from the expected profit in making the decision, therefore, he should not believe. This is assuming that the festival will be held in the distant future. So that, there is no prediction that depends on the weather, and the insurance rate depends on this fact well. Insurance rates usually depend on the previous experience. But it can also depend on prediction with an event during a short enough time, the correct prediction is possible.

We assume that the meteorological records indicate that 80% of the day of this period are weather. The proper decision in this not to purchase (insurance policy). The question now is : how much is it expected to gain more than his gain if he bought an insurance policy?

The accounts will be using the formula (1) and the formula (2); and the given values are:

E1 = 15.400

En = 16.400

Therefor; the financier will expect to earn : 1000$ more than gained if is purchased for an insurance policy.

As for the financier who feels that the cannot take the risk of reducing his profit to : 2000$ in rain, we cannot apply the philosophy of relying on decisions on the expected profit that we discussed in his condition all.

2. Evaluating information

Depending on the previous discussion, it is natural for a question to appear on how to take advantage of the information resulting from experience to improve the accuracy of the decisions making. In the problem that was previously discussed, we cannot do this to improve valuable estimate : p that we got from the records, unless we wait for a short period of time before the event to get a reliable weather forecast.

If the insurance costs do not increase. This information can have value. But problems that include the possibilities can be calculated from the samples, the decision making process can improve the use of information from these sampled.

Here we will consider the evaluation of non-specific information, and on the other hand we will study the evaluation of the information we obtain from the samples.in the problem that was previously discussed: the possibility of the atmosphere on the previous meteorological records for the same period, and the value of the possibility was : p = 0.8.

We assume that the meteorology man who does this service : suggested man who does this service: suggested that the financier provide the weather within a week before event, for an amount : 200$. These records are useful that its predictions are intact in : 75% of cases.

Issue now : it becomes account if the cost of prediction will be replaced by the increasing profits. Now, there are three potential procedures, because the financier can use the meteorological man only, in the event that the estimate indicates a state of rain. The other two possibilities are : insurance, or no insurance, without the help of the meteorological man. Instead of only two weather, and here we have four weather estimates that must be taken into consideration, these cases are shown in the payment schedule represented in table (3).

Table (3)

Event	Possibility	procedure		
		Insurance	No insurance	prediction
1-Weather and forecast are clear	(.8)(.75)=0.60	15.000	20.000	20.000
2-Weather is clearer prediction is rainy	(.8)(.25)=0.20	15.000	20.000	15.000
3-Weather is rainy, pred. is clear	(.2)(.25)=0.05	17.000	2.000	2.000
4-Weather is rainy, pred. is rainy.	(.2)(.75)=.15	17.000	2.000	17.000

3. Expected profit accounts

The expected profit is calculated under the three possible procedure (table:3), it is done in the usual way, and according to the following:

E1=15.000 (0.60)+ 20.000 (0.20) + 2.000 (0.05) + 2.000(0.15)

∴ E1 = 15.400

En = 20.000(0.60)+15.000(0.20) + 2.000(0.5) + 17.000(0.15) = 17.650

∴ Ef = 17.650

Thus, the values will be : En and E1 are the same values that we got as precedent that we got as a precedent for a value : p = 0.8

This is because the estimation of the meteorological man was not used in these two procedures. Since the best procedure that was the lack of insurance, therefor: the gain in the expected profit by taking advantage of the services of the metrological man is:
17.650 – 16.400 = 1250

From these accounts, we find that:
Metrological man advice = 1250$ → Expensive profit.
Therefor: the financier will be happy if the pays it : 200 $ for the advice.

We assumed that in these accounts: the insurance company welcomed that the insurance will be a week before the event at the same costs, and without the use of metrological men to determine new costs for insurance.

Previous steps describe what is applied to large practical situation, the problem in which the expected profit calculate, and can it increased by buying certain information? Or, whether the gain from using this information exceeds all of it?

4. Utilizing New Information; Sampling

We considered the problem of using and evaluating the information that we get from sources and not from samples (as mentioned above). So we will discuss in this section: how to calculate the decision-making process using the sample.

To clarify this, we will present the following supposed. After solving this issue, these same methods will be applied to solve real practical problems.

4.1. Example

A box contains three currencies, two of which are regular, and the third currency has a face on each side. What is required : with drawing one currency from the box. The problem is: determine whether the withdrawn currency, a combined currency, or a withdrawn, a combined currency, or a currency with two sides. The payment schedule for the two possibilities is shown in table (4):

Table (4)

	Action	
Currency type	Choose a regular currency	Choose a two-sided currency
Regular two-sided	9	-6
	-12	15

Accounts required to determine the expected profits under the two potential decisions are made in the usual way and is shown in table (5).

Table (5)

Currency type	**Tribe possibilities**	**Regular test**		**Test of the two sides**	
		profit	**Expected profit**	**profit**	**Expected profit**
Regular	2/3	9	6	-6	-4
two-sided	1/3	-2	-4	15	5
The total	1		2		1

Since the expected profit is : 2 if the decision is in the interest of the two-sided currency, while it is in favor of the regular currency, to take advantage og the additional information that can obtained from an in-kind experience. We assume that withdrawn currency has been thrown three times and we got three faces.

The additional information will participate in the analysis, by calculating a new set of possibilities to replace the possibilities mentioned in the second column of the table (5).

These last possibilities of values : 2/3 and 1/3 are called previous possibilities for this issue, because they are the possibilities available before conducting the in-kind experience.

After providing the results of the in-kind experience, it is possible to use bays theory to calculate better estimates of these possibilities, because it is : the possibilities that were applied after the experiment, in-kind results were used to calculate the new possibilities, if the two events were in the first column in table (5) ; they distinguished the simple : T and R tribal possibilities are given by.

P {R} = 2/3 and P {T} = 1/3.

If it is : S| the results of the sample symbolize, that is, the results of obtaining three aspects in three throws of currency. Therefore, the dimension is given with the following symbols:

P {R|S} and P {T|S}.

These remote possibilities are counted using the pose format and using : bays theory, by the following:

$$P\{R|S\} = \frac{P\{R\}.P\{S|R\}}{P\{R\}.P\{S|R\} + P\{T\}.P\{S|T\}}$$

Although the value of: P{T|S} can be obtained by offering : P{T|S} from 1, it is better to calculate : P {T|S} directly from the : bays formula; to avoid possible errors in the account. The conditional possibilities; P{S|T} and P {S|R}, that you need here, relying on three successes in three independent attempts and their values as follows:

P {S|R} = 1/8 and P{S|T}= 1

Thus it will be :

P {R|S} = (2/3 * 1/8) / (2/3 * 1/8 + 1/3 * 1)

P {T|S} = (1/3 * 1) / (2/3 * 1/8 + 1/3 * 1) = 4/5

The analysis is now according to the previous method with the replacement of tribal possibilities in the second column of the schedule : 5 with the remote possibilities that were calculated. These accounts are shown in table (6).

It is now necessary to reflect previous decision to with drawing a currency with two sides. The difference in expecting is now a perceived value compared to the previous difference before conducting the in-kind experience.

Table (6)

		Regular currency test		Test of the two sides	
Currency type	**Precise possibilities**	**profit**	**Expect profit**	**profit**	**Expect profit**
regular	1/5	9	1.8	-6	-12
Two sides	4/5	-12	-9.6	15	12
The total	1		-7.8		10.8

4.2. Application

Previous (virtual) methods will be used to solve real problems, and as follows:

A product for a bit complicated commodity like cars: usually it is facing the problem of the test size and examination, and the experience to be executed in the factory before shipping these purposes to the distributor. The producer may search and agree to pay the costs of any repairs requested by customers after returning the commodity to the distributor as a result of some of the faulty parts, or improper manufacturing, or instead: this is to exclude most of the compensation required by the distributor.

We assumed that the produced commodity: a car, and we assume that the cost of the test is: 24 $ per car in the factory due to a grouping error or an error in the manufacture of parts, in addition to: another 20 $ the product is sponsored by a defective car in the right place. On the other hand, if we assume that the product costs: 80 $ for each other care on average to fix the defects discovered by the customer, due to the failure to check and search the car inside the factory as required. We will also assume that the factory inspector and customers discover the same percentage of defective cars.

We are now assumed that the product keeps a weekly record for the percentage of tired cars produced in a production line. We will express this experience as shown in table (7), special value ; P {Pi} is the ratio of these weeks when the part of the defective cars is the value Pi.

If it is 10% (as an example) of these weeks, we find that 60% cars have one or more defects. All of these parts and proportions will be crossed in the form of a decimal for the nearest tenth sign.

Table (7)

Pi	0.2	0.3	0.4	0.5	0.6
P{Pi}	0.2	0.2	0.3	0.2	0.1

If we assume: that the current type of production similar dependent on previous experience, so that: a schedule values:7 will be used to calculate the expected losses of potential atmosphere, they are: inspection within the factory: (F), or: the implementation of the customer′s requests: (C). To implement this: we must understand: that we will not consider some important factors such has the capacity of the production place, explaining the needs and the relationship of distribution to consumption.

These unfinished matters that appear in any steps to make the decision, we will overlook them, taking into consideration the overlook them, taking into consideration the expected losses of losses depend on the expense of losses for each value of the values: Pi and the collection of all these losses.

We assume that : N : a car that produced within a continuous production week, we assume that : n : a car that was produced within a continuous production week, and that the part : Pi : from this production has one or more defects, and because of the examination the loss of the product was: 24 $ and to repair : N is a specific car : Npi : 20, so the college will be like the following:

Lp = 24N + 20 Npi

In the event that the examination is not completed inside the factory, the product costs will be : 80 Npi dollars as compensation for the model, that is :-

Lc = 80 Npi.

Accounts of these expected losses of values : Pi different, explained in a : table (8), in light of these accounts, the appropriate decision will be: Allow the distributor to repair compensate for cars and compensate for costs:

Table (8)

		Factory examination		Customer complaint	
Pi	**P{Pi}**	loss	Expected loss	Loss	Expected loss
0.2	**0.2**	28N	5.6N	16N	3.2N
0.3	**0.2**	30N	6.0N	24N	4.8N
0.4	**0.3**	32N	9.6N	32N	9.6N
0.5	**0.2**	34N	6.8N	40N	8.0N
0.6	**0.1**	36N	3.6N	48N	4.8N
∑	**1**		31.6N		30.4N

If we impose a doubt that confirms that the quality of the current production is different from the previous production, by improving the previous steps by : taking a sample of current production and involving it in the decision- making process the biz format and in the same way, those that were used in the previous currency.

To clarify : we assume that we have : a random sample of : 50 cars that were taken from the current production, then : after a comprehensive examination and inspection, it was found that there are : 25 : cars with one or more defects.

These cars can be treated : as fifty attempts to try the possibility of success in them (the presence of a defective car) is : P, and the number of times the success of the incident is : 0.25 and as result : the two-limited distribution can be applied to his problem of taking this samples to help in conducting the tribal possibilities accounts of this problem.

If it is : S symbolizes : 25 success, that the result of : 50 attempts in the in-kind experience, therefore, the remote possibilities required to replace to tribal possibilities are : P {Pi |S} : bes formula for this problem, which is:

$$P\{Pi|S\} = \frac{P\{Pi\}P\{S|Pi\}}{\sum_{i=1}^{5} P\{Pi\}P\{S|Pi\}} \quad (3)$$

Since the distribution of the two limits is applied in this in-kind experience, therefore, the conditional possibility of this formula will be according to the following formula : by compensation in ; (3) for each value of values ; P {Pi} in table (8). To clarify this, be accounts : P {P3|S}

$$P\{ S|Pi \} = \frac{50\,!}{25\,!\,.25!} \; Pi^{25(1-Pi)^\wedge 25} \tag{4}$$

We conclude from the two equation : (3) and (4) the following :

$$P\{P3|S\} = \frac{(0.3)\frac{50!}{25!\,.25!}\,(0.4)^{25} * (0.6)^\wedge 25}{\sum_{i=1}^{5} P\{Pi\}\frac{50!}{25!\,.25!}\,(Pi)^{25(1-p)^{25}}}$$

$$= \frac{(0.3)(0.4)^{25} * (0.6)^\wedge 25}{\sum_{i=1}^{5} P\{Pi\} * (Pi)^{25(1-p)^{25}}} = 0.312$$

The results of these accounts will be shown in the second column of table (9), it will also clarify the accounts required to obtain the expected losses in light of the distant possibilities.

We note that the information used from the sample reflected the previous decision. It has appeared to be better economically due to the high percentage of defective cars in the sample, therefore; accurate inspection should be done inside the factory, while: before : the opposite is the most appropriate economically. They type of production also appears : less efficient than previous production.

Table (9)

		Factory examination		Customer complaint	
Pi	**P{Pi|S}**	**loss**	**Expected loss**	**Loss**	**Expected loss**
0.2	0.000	28N	0.00N	16N	0.00N
0.3	0.007	30N	0.21N	24N	0.17N
0.4	0.312	32N	9.98N	32N	9.98N
0.5	0.577	34N	19.62N	40N	23.08N
0.6	0.104	36N	3.74N	48N	4.99N
∑	1		33.55N		38.22N

5. Conclusion and recommendation :-

1. Table (2) : explain : the more clear the atmosphere, less the need for insurance.
2. The sports financier must consult the meteorological department for the period in which the sports festival will be held, to find out the percentage of the serenity of the atmosphere in those days:
   - **A.** When increasing : 0.75 : when achieving this and being ready to benefit from the expected profit in the decision-making.
   - **B.** He must : he does not believe, this is assuming that the festival will be held in the distant future that there is a prediction of the weather.
   - **C.** The insurance rate depends on this fact as well.
   - **D.** The adoption of insurance rates is usually on the previous experience and prediction (estimate) within a short sufficient period of time, in which the correct prediction is possible.
   - **E.** The financier will expect : 1000 $, more than his gain if he purchases an insurance policy.
   - **F.** The financier who feels that he cannot take a risk of having his profit to : 2000 $ in rain, the philosophy of relying on decision on expected profit will be not possible.
3. The presence of three procedures (not only two) :-
   - **A.** The possibility of the financier is that the meteorological man must believe in the state of the presence of the rain or not.
   - **B.** Insurance or not without using the forecast of the meteorological man.
   - **C.** Instead of only two weather conditions we will have four weather estimates.
   - **D.** These cases are shown of in the payment schedule represented in a table (3).

4. Take advantage of the service of the meteorological man because his advice is equal to 1250$: expected profit, so the financier will be happy when payment it : 200 $ for this.
5. Insurance companies welcome insurance a week before the event and at the same cost without the use of meteorological men to determine new costs : this is an assumption in the accounts mentioned.
6. Allow to the distribution to repair and compensate for car defects : table(8).
7. Schedule : (9) explain : the accounts required to obtain the expected losses in light of distant possibilities.
8. We note that the information used from the sample : reflected the previous decision. It turns out that it is better economically, due to the high percentage of defective cars in the sample.
9. Frank inspection should be inside the factory, unlike the previous: it was the most appropriate economically.
10. Therefore, the type production appears less efficient than the previous production : table (9).

References

[1] Black Well, T,W, An introduction to multivariate statistical analysis, John Wiley and Sons, New York, 1958.

[2] Basu, D., “On statistics independent of complete sufficient statistics, Sankhyā: The Indian Journal of Statistics, Vol. 15, No. 4, 1955.

[3] Black Well, D. and Grishick, M,A., The theory games and statistical decision, John Wiley and Sons, New York, 1954.

[4] Carpenter, O., “Note on the Extension of Craig's Theorem to Non-Central Variates″, Ann. Math. Statist. 21(3): 455-457, 1950.

[5] De Groot, M.H. Probability and statistics, 2^{nd} edition, Addison-Wesley Series in Mathematics, Addison-Wesley Publishing. 1986.

[6] Zuwaylif, F.H., General Applied Statistics, 3rd edition. Addison-Wesley Publishing, Philippines, 1979.

مجلة كلية الرافدين الجامعة للعلوم (2023)؛ العدد 54؛ 576 - 584

AL- Rafidain University College

PISSN: (1681-6870); EISSN: (2790-2293)
مجلة كلية الرافدين الجامعة للعلوم

Available online at: https://www.jrucs.iq

JRUCS
Journal of AL-Rafidain University College for Sciences

الانحدار غير الخطي المتعدد وتطبيقاته

أ.م.د. عابدة أحمد الطائي

abida@ruc.edu.iq

كلية الرافدين الجامعة، بغداد، العراق

المستخلص

يعكس الميل غير الخطي خصائص معلمات النموذج لتقدير قيم المتغير المعتمد، ويكون عدد المتغيرات المستقلة اثنين أو أكثر، ويتطلب النموذج غير الخطي عملية تقريب معقدة في النماذج غير الخطية الذاتية، والتي لا يمكن تحويلها إلى علامة α عن طريق إجراء تحويلات معروفة.

معلومات البحث

تواريخ البحث:
تاريخ تقديم البحث: 2023/1/14
تاريخ قبول البحث: 2023/3/3
تاريخ رفع البحث على الموقع: 2023/12/31

الكلمات المفتاحية:
الانحدار، القيم المتعددة غير الخطية، القيم المحولة، معيار كفاءة النموذج، المعلمات..

للمراسلة:
د. عابدة أحمد الطائي
abida@ruc.edu.iq

https://doi.org/10.55562/jrucs.v54i1.625