

# *A Study of the Use of Mathematical Models in a Blind Box Economy*

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**Abstract:** Since 2016, blind boxes have been loved by consumers, and the blind box economy has exploded. However, the blind box economy is closely linked with mathematical models. The mathematical models could be research predictions of profit and loss in blind boxes. Such functions as the loss function can assess the purchase probability of the blind box as well as how to avoid massive losses. Neural networks and Linear regression can predict the price changes of the blind box. Besides, we can predict and analyze the psychological and behavioral motivations of consumers. Therefore, the passage through literature reading and specific data analysis methods focuses on the mathematical models such as Loss function, Neural network and Linear regression that are applied in the blind box now. And the passage also describes the predictional model of profit and loss contradiction to avoid consumers consuming excessively 'a pig in a poke'. At present, Linear regression can analysis and calculate investment with the blind box, but it should consider a lot of factors that can cause errors. Neural network can predict price changes, and it needs a large amount of data to support the model. Loss function can be used to predict the profit and loss of a blind box, but it also needs a large amount of data to prove its accuracy.

**Keywords:** Neural network, Loss function, Linear regression, blind box economy, behavioral motivation

## 1. Introduction

Blind Box Economy is the top-ranked designer toy. In the present time, the blind box is very popular. Such as POPMART is very popular in the blind boxes. Its income was 44.91 billion RMB in 2021. In comparison to 2020, it has grown by 78.7% year over year. In addition, POPMART has added 108 offline stores in 2021. 66.78% of the POPMART offline store is in first-tier cities and new first-tier cities. And on average, only one POPMART offline store in first-tier cities has a one-year income of just 705.7 million (RMB). Molly series annual income will be 705,098,000 (RMB) in 2021; SKULLPANDA series annual income will be 595,256,000 (RMB); Dimoo series annual income will be 566,735,000 (RMB); and "Sweet Bean" series annual income will be 161,526,000 (RMB). And other own IP annual income of 390,329,000 (RMB). Own IP The monster annual income is 304,431,000 (RMB); the PUCKY annual income is 182,224,500 (RMB). Other own IP annual income is 283,831,000 RMB; total non-exclusive IP and consignment et cetera income is 1,133,317,000 RMB in 2021. Total income: 4,490,651,000 (RMB) in 2021 [1]. Therefore, the passage tries to find out the connection between mathematical models and the blind box

economy and analyze the psychology of consumers buying the blind box. At the same time, the passage elaborates on the behavioral motivation of consumers buying the blind box, loss function, purchase probability, and avoiding too many losses. Neural network and Linear regression to predict the changes of price of blind box. The passage uses research methods such as theoretical analysis to find data. The passage improves the research in the blind box by combining mathematical models to perform data analysis. For economic data statistics and risk assessment, psychological behavior, blind box economy, data analysis, and other subjects.

## **2. Consumption motivation**

Now, many consumers very much like air toys and figures, and air toys and figures spend the most. The sales volume in Tmall year-on-year growth was 189.7% [2]. At the same time, the air toy and the figures are more and more in line with public aesthetics and preferences. Actually, the figures' blind box does not have any practical use, but the exquisite design of the blind box makes the consumers fondle admiringly. Firstly, some blind boxes with games and film signs jointly, such as POPMART and Molly series, "man of Tomorrow" limited edition, "I only love you and Molly wedding series, Ponds, Nivea, etc. It let its intellectual property have the "freshness" and the "heat". Maybe someone is a fan of games or films, and he or she will buy the blind box. A set of blind boxes consisting of many blind boxes may be popular with consumers, just like one of the blind boxes. In that case, the consumer will have two options. Option 1: Purchase only one blind box from the set of blind boxes until the consumer has the blind box desired. Option 2: Just buy a whole set of the blind box. If you are unlucky, Option 1 could cost more than Option 2. air toy and figures blind box sign jointly with others, expand the popularity and the scope of publicity, let more people know their blind box brand, attracted more people's attention and curiosity about the product, which will drive people to consume. Secondly, the price of a blind box is not very high; the general average is about 10-100 (RMB), most of which are about 30-60 (RMB), and many students can afford it too. The blind boxes are more and more creative, and many stationery blind boxes are more attractive to students. If one student uses the statistics blind boxes, other students will see them, and there will be curiosity, like comparison and other psychology. So some students will follow the trend to buy blind boxes, resulting in a chain reaction that will encourage more students to buy blind boxes. In 2016, the first Molly series online store, POPMART, sold each set of blind boxes for 708 RMB. Just four seconds after the sale, 200 sets of the Molly series were sold out. At the same time, the offline stores will also be out of stock soon after the sale. In 2021, the revenue of Molly series products was 705 million (RMB), accounting for 15.7% of the total revenue of POPART. The POPMART Molly series is so popular because it guarantees the uniqueness of IP and the initiative of IP on the Chinese mainland. Molly in the Chinese Mainland only signed a POPART joint, so Molly's fans only bought their favorite style of POPART.

## **3. Neural network and Linear Regression to Predict the Price Change of Blind Box**

Neural network is an adaptive system that is established by simulating the nervous system of the human brain. Neural networks learn from data and can be used to recognize patterns, classify data, and predict future events. The neural network can also learn by itself; just by first entering a large number of different image templates and corresponding methods, the neural network system will gradually learn to recognize similar images. The self-learning function of prediction is of great significance to the development of the blind box economy. If only for a problem to create a way of the feedback artificial neural network training, so it can play a neural network computing ability, compared to others, it can be faster to find the optimal solution to the problem. And after a lot of training, the neural network will mimic the way the brain works by dividing the input speech or

image into multiple abstraction layers. The neural network converts the data features of each layer or the features in the part of the picture into numbers, so some data is lost and the picture may not be as sharp. The output of the neural network is determined by the connections of the individual "neurons" and the strength and weight of each layer of the algorithm. These weights are constantly adjusted automatically in order for the artificial neural network to produce the desired results. But once there is not enough data to support it, the neural networks cannot carry out identification, prediction, and other work.

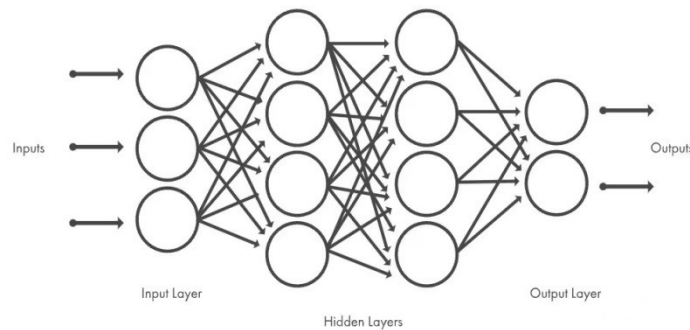


Figure 1: Neural network

Neural network is divided into shallow neural network (as shown in Figure 1 ) and deep neural network A shallow neural network is generally divided into three layers: the input layer, the hidden layer, and the output layer[3]. Linear regression is the analysis and modelling of the relationship between one or n independent variables and dependent variables (using the least square method of linear regression equation  $y = ax + b$ ) expressed by Linear regression line calculation is very simple, and modeling is convenient and fast. At the same time, the significance and meaning of each variable can be given according to the equation coefficients of modeling. However, if the data is non-linear, the fitting results may have very large deviations from the accurate values. Therefore, in order to draw an accurate conclusion, it is necessary to judge whether the relationship between independent variables and dependent variables is linear or not. The linear model is easier to explain, so it is popular with scholars in economics, medicine (mainly for epidemic disease), and business. The concept of linear regression for blind box economic analysis and calculation of investments are derived directly from the model coefficients of investment returns and returns for all risky assets. The independent variable is the number of blind boxes, and the related variable is the number of times the consumer buys the desired blind box for the purchase. This has ensured that the effect is not caused by other factors such as income differences; however, empirical analysis cannot include all the factors that cause error, so randomized controlled trials are more realistic and reliable than data observations[4].

#### 4. Loss function and consumer profit and loss

The loss function is to express the value of the random event in the form of a function  $(\Omega, F, P^\theta)$  is the sample space,  $\theta \in \Theta$  s the testable state in the sample space,  $x$  is a random variable,  $P^\theta$  is an algorithm,  $d \in D$  is  $x$  (random variable) according to  $P^\theta$  (algorithm),  $\Theta \times D$  is a product space,  $(\theta, d)$  is a function. If there is a function  $(\theta, d)$  satisfying any  $\theta \in \Theta, d \in D, L(\theta, d) \in [0 + \infty]$ , and in  $\Theta \times d$  product space, that is, for any  $\theta \times d$  (product space)  $\in \Theta \times D L(\theta, d)$  is a non-negative measurable function, then  $L(\theta, d)$  is called the loss function, in order to represent the state  $\theta \in F$  to take a decision  $d$  corresponding to the loss or risk [5, 6].

$$L(y, \hat{y}) = \text{distance}[f(X, w), p(y|X)] \quad (1)$$

Suppose that there are a total of  $m$  ( $m > 0$ ) sets of blind boxes; a set of blind boxes has  $b$ ; buy the first blind box loss; buy the second blind box loss.  $2n$  Yuan,  $3n$ ,  $4n$ ... The following abscissa is the number of blind boxes purchased, and the loss function of all sets of blind boxes is superimposed, and the loss function of the buyer as a whole must be a parabola, so there must be a most value point (the most appropriate point) on the parabola. If the number of blind boxes purchased deviates from this optimal point, there will be additional losses. When the parabola is tangent to the abscissa axis, there is a short distance to the left and right of the tangent point, and the loss is small enough to be almost negligible. However, the further away from the optimal point, the greater the loss. If you can have a specific number of loss function cases, the optimal point can be calculated, and the optimal point of the most economical cost is the coordinate of this point. But the 0-1 loss function (a non-convex function) does not apply. Because 0-1 is more suitable for judging right or wrong or choice, such as the question of whether the student passed, the loss function is a one-fit result that requires a large amount of data, and if a small amount of data is used, the chance may be large and may not be convincing.

## 5. Conclusion

A blind-box economy drives economic development. There is a great relationship between the mathematical model and the blind box economy. The passage with the "Loss function can assess the purchase probability of the blind box as well as how to avoid massive losses. Neural networks and linear regression can predict the price changes of the blind box. Besides, we can predict and analyze the psychological and behavioral motivations of consumers. " To unfold. At present, Linear regression can analyze and calculate investment with the blind box, but it should consider a lot of factors that can cause errors. A neural network can predict price changes, and it needs a large amount of data to support the model. Loss function can be used to predict the profit and loss of a blind box, but it also needs a large amount of data to prove its accuracy.

The passage has few examples in this paper, and the conclusion is not universal, so we should collect more data on ancestor worship. And this paper only includes some mathematical models (linear regression). Loss function and neural network) will expand the scope of mathematical research models in the future and expand the scope of research samples, as well as the scope of research, so that the conclusion is more universal. In this paper, the psychological behavior of people buying blind boxes is not fully explained, and all the favorable and unfavorable factors should be considered.

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