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Research on the issue of maternity policy

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Abstract: *We establish a mathematical model for calculating fertility costs and fertility willingness, and analyze the index system of factors affecting the fertility costs of ordinary Chinese families. Firstly, we obtain the initial weights through the AHP method, and then construct the envelopes of the weights and fitted the curves. In addition, the BP neural network is used to predict the population growth with or without the three-child policy, to obtain the population in the next three years, and study the difference between the two to obtain the ratio of the difference to the population growth without the three-child policy, thereby obtaining the three-child policy. Finally, the main factors affecting fertility willingness and fertility cost at home and abroad are studied.*

Keywords: *AHP, BP neural network, envelope, multiple nonlinear regression*

1. Research background

This question is mainly aimed at the current national policy of opening up to three children, finds relevant indicators of population fertility, conducts data analysis and mining for them, provides relevant mathematical models and strong scientific basis, and gives relevant suggestions to better improve the country. The benefits of the three-child policy to avoid the occurrence of population aging.

Firstly, according to the existing domestic production indicators and other data, analyze the indicator system that affects the factors affecting the childbirth cost of ordinary Chinese families, first obtain the initial weights through the AHP, and give feasible measures, then construct the envelope of the weights and fit them curve [1]. Establishing a mathematical model for calculating fertility costs and fertility willingness.

Secondly, according to the existing population growth in China, the BP neural network is used to predict the population growth with or without the three-child policy, and the population in the next three years is obtained, and the difference between the two is studied to obtain the difference and the three-child policy [2]. The ratio of population growth to obtain the impact of the three-child policy on the fertility rate.

Finally, the main factors affecting fertility willingness and fertility cost at home and abroad are basically the constraints of economic conditions. Therefore, mathematical models and population forecasts are established by liberating brokerage constraints and supplementing financial support as a way to reduce fertility costs.

2. AHP model

The problem to be solved is hierarchically serialized, that is, according to the problem [3], it is decomposed into different components, and the hierarchical clustering is combined according to the interaction and membership between the factors to form a hierarchical and ordered hierarchical structure model. As shown in Fig. 1.

Through the survey data, it can be seen from Fig.1 that the influencing factors are mainly affected by four aspects: economic cost, labor cost, opportunity cost, and family concept. Among them, the above four aspects can be divided into: pre-pregnancy preparation cost, time cost and physical energy cost, work cost and other development costs, elder concept and self concept.

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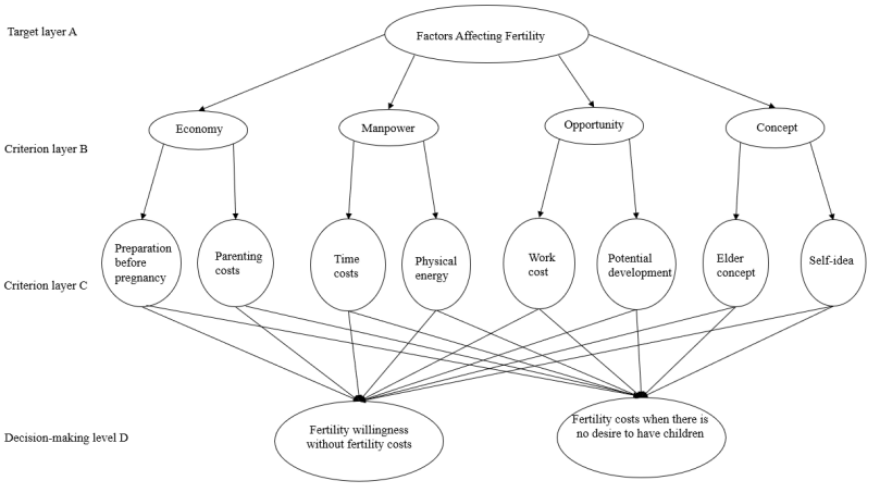

Figure 1: Stratification of influencing factors

According to the degree of importance, a discriminant matrix is established as shown in table 1.

Table 1: Discriminant matrix element table

standard value	The importance of b_i to b_j compared to element b_i compared to b_j
1	equal importance
3	slightly important
4	obviously important
7	strongly important
9	extremely important
2,4,6,8	the above-mentioned adjacent judgment median
reciprocal	$b_{jt} = 1/b_{ij}$

Taking the target layer A and the criterion layer B as an example, the results in table 2 are obtained.

Table 2: The discriminant element table of target layer A and criterion layer B

A	B1	B2	B3	B4
B1	b_{11}	b_{12}	b_{13}	b_{14}
B2	b_{21}	b_{22}	b_{23}	b_{14}
B3	b_{31}	b_{31}	b_{31}	b_{34}
B4	b_{41}	b_{42}	b_{43}	b_{44}

The relationship between hierarchical single ordering and consistency check is:

$$DV = \lambda_{max} V \tag{1}$$

Where D is the judgment matrix, λ_{max} is the maximum eigenvalue of the judgment matrix, V is the eigenvector of λ_{max}.

Each element in the judgment matrix should theoretically satisfy:

$$b_{ij} = \frac{b_{ik}}{b_{kj}} (i, j, k = 1,2, \ldots., n) \tag{2}$$

However, in actual analysis, due to the complexity of objective things and the differences in the understanding of different experts, it is impossible for each judgment matrix to be completely consistent. In order to examine whether the judgment matrix is suitable for AHP, it is necessary to do a consistency check. In order to check the consistency of the judgment matrix, it is necessary to calculate the consistency index:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \tag{3}$$

When the matrix order n is greater than 3, its consistency is corrected:

$$CR = \frac{CI}{RI} \tag{4}$$

The matrix weight normalization process can be expressed as:

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$$\bar{b}_{ij} = b_{ij} / \sum_{k=1}^{m} b_{ij} \tag{5}$$

Calculating the weight vector of the target criterion layer as:

$$\mathrm{V} = (v_1, v_2, v_3, \dots, v_k) \tag{6}$$

Where v_i is the relative weight of the criterion layer index i in the criterion layer.

Assuming that for the k-th criterion-level indicator, the weights of the measure-level indicators under each criterion are:

$$V_k = \left(v_{k1}, v_{k2}, v_{k3}, \dots, v_{kp}\right) \tag{7}$$

Then in the hierarchical structure, the comprehensive weight calculation operator of the measure j index under criterion i is:

$$v_{i \cdot j} = v_i \cdot v_j \tag{8}$$

Different from the conventional direct comparison of final weights to obtain conclusions, this model adopts the calculation of family fertility rate to obtain the critical situation of fertility willingness and fertility cost [4]. It is stipulated that all sample weight points are the set of horizontal and vertical coordinate points, and the connection line is the tangent family $\mathrm{F}(x, y, C)$:

$$\mathrm{y} = \frac{C-1}{C} x + 1 - C \tag{9}$$

$$\mathrm{F}(x, y, C) = y - \left(\frac{C-1}{C} x + 1 - C\right) \tag{10}$$

Getting the fitting function expression:

$$(1 - x - y)^2 = 4xy \tag{11}$$

In order to simplify the calculation process, we first normalize the two sets of criterion layers, and integrate the two layers into one layer, as shown in Fig. 2.

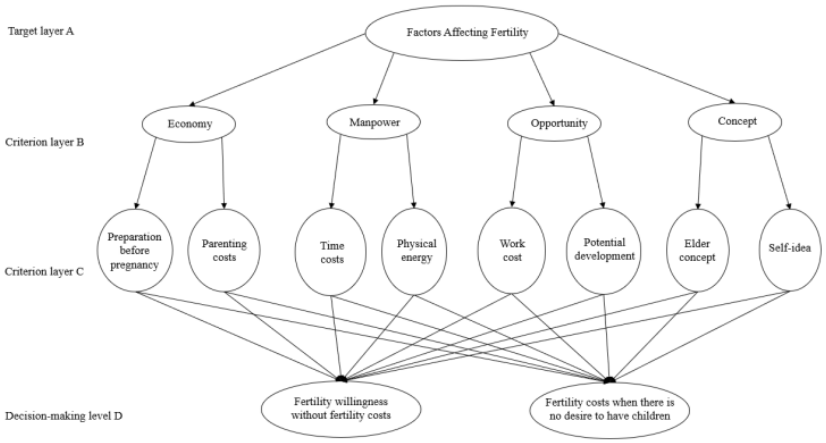

Figure 2: Simplified layering

After investigation, the weight distribution of a group of families was selected. After processing, the data are shown in table 3.

Table 3: Normalized weight distribution

B / C	B1	B2	B3	B4	B5	B6	B7	B8	Total sort
	0.1299	0.0071	0.1683	0.1851	0.1345	0.1502	0.1473	0.0777	
1	0.7929	0.8571	0.1055	0.6836	0.5349	0.4905	0.2762	0.4081	0.471384
2	0.2071	0.1429	0.8945	0.3134	0.4651	0.5095	0.7238	0.5919	0.528616

It can be seen from the data table that the AHP model is correct and reliable. At the same time, a linear functional relationship is drawn based on 10 groups of sampled household data. Draw the envelope as shown in Fig. 3.

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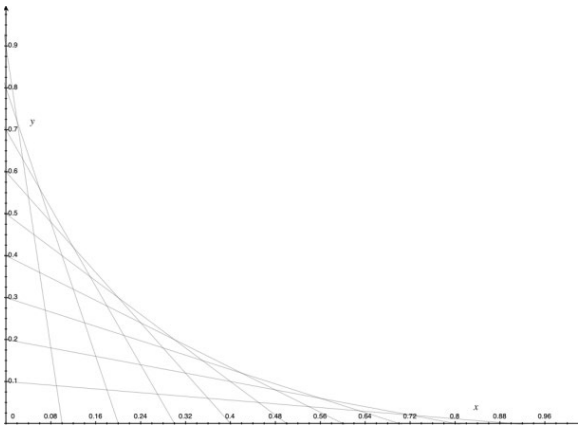

Figure 3: Weight line

According to the comprehensive weight of family samples in the sampling survey, the envelope image of fertility willingness and fertility cost is drawn. After removing all straight lines, the curve is fitted, and the obtained curve is the mathematical model of fertility willingness and fertility cost. Selecting a set of samples to remove the redundant tangent family, let the fertility cost be C2, and the fertility willingness to be C1 for explanation. The results are shown in Fig. 4.

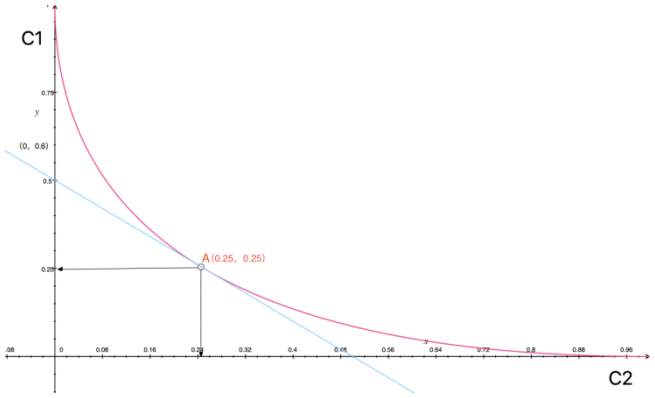

Figure 4: Sample data display

When the corrected weight point is A(0.25,0.25), the intersection points of its tangent and the coordinate axis are C1(0,0.5) and C2(0.5,0) respectively. It is expressed as: when the fertility willingness is not considered, the family's fertility cost is 0.25, and once the fertility willingness is considered, its fertility cost becomes 0.5; when the fertility cost is not considered, the family's fertility willingness is 0.5. Fertility cost, its fertility willingness will become 0.25.

The above results can intuitively and clearly reflect that when a family does not consider the cost of childbirth or the willingness to bear children, the cost of childbirth or the willingness to bear children of the family tends to be normal [5]. When one indicator is considered, another indicator will have a significant inhibitory effect on it. In line with the actual situation of life, it also shows the reliability and rationality of this model. At A(0.25,0.25), the slope of the envelope is equal to the slope of the straight line and there is only one intersection.

3. BP neural network model

The expression to get the global error:

$$E = \frac{1}{2}\sum_{p=1}^{p}\sum_{k-1}^{l}(d_k - y_k)^2 \tag{12}$$

Study the impact of the three-child policy on fertility and calculate the population growth in the next three years, so we first predicted the population growth in the next three years without the implementation of the three-child policy, and then implemented the implementation of the three-child policy. The difference in expectations between them is the impact of the three-child policy on population growth. The final prediction results are shown in table 4.

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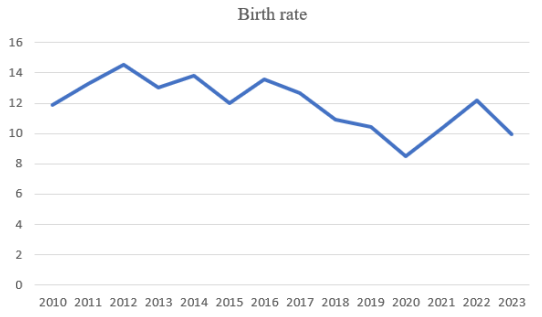
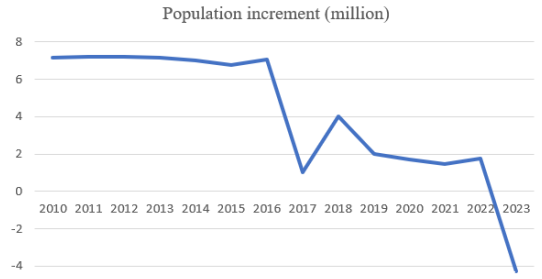
Table 4: The impact of the three-child policy on fertility

	2020	2021	2022	2023	Unit
With policies	141178	142636	144377	143948	million
No policies	141178	141766	142305	140888	million
Difference	0	870	2072	3060	million
Policy fertility rate	1.01	10.32	12.20	9.95	%
No-policy fertility rate	1.01	4.16	3.80	-2.97	%
Birth rate impact	0	6.13	14.56	21.71	%
Population increase	170	1458	1741	-429	million

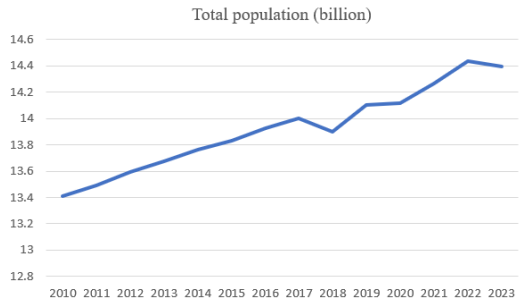
The trend chart is shown in Fig. 5.



(a) Projected birth rate



(b) Population growth



(c) Total population trend

Figure 5: The trend chart

As can be seen from Fig. 5, after the country implements the three-child policy, the number of births will increase by 8.7 million, 20.72 million, and 30.6 million in 2021, 2022, and 2023, respectively.

The main factors affecting fertility willingness and fertility costs at home and abroad are basically constraints of economic conditions. Therefore, this group uses the specific data of 2020 as the support to liberate brokerage constraints and supplement financial support as a way to reduce fertility costs. This builds mathematical models and population forecasts.

A sampling survey was conducted to count 10,000 family samples, and after the state subsidized 58,000 yuan, a survey on the willingness to have three children was conducted. A total of 102 groups of data have obvious willingness to bear children, accounting for 1.02%. The national fertility rate in 2020 is 0.852%, and after giving birth subsidies, the fertility growth rate β is 20.1%.

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4. Sensitivity analysis

Selecting the impact of economic cost on the model for sensitivity analysis, taking the three groups of well-off, high-income, and low-income families as the target, the following conclusions can be drawn: when the family tends to be richer or poorer, the family's willingness to bear children increases. High, basically higher than the fertility willingness of well-off families [6]. In line with the willingness to bear children in today's society in my country, high-income families do not have the trouble of childbearing costs, so they are willing to have children; the economic situation of low-income families is already very low, and under the premise of high childbearing costs, having one more child is a family. The impact of economic burden is not large, so low-income families will have more children to hope that children will change the family's economic status; well-off families are in the stage of class transition and basically focus on career, so their willingness to have children will be low, which is in line with today's social conditions .

Extending the time span and predict the population growth in the past ten years through the BP neural network. Taking the prediction data of the BP neural network as the sample data, the significance test of the equation can be expressed as:

$$\mathrm{SSR} = \sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2 \tag{13}$$

$$\mathrm{SSE} = \sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2 \tag{14}$$

$$\mathrm{F} = \frac{SSR/k}{SSE/(n-k-1)} \sim F(k, n-k-1) \tag{15}$$

For a given significance level α, the rejection area of the test $\mathrm{F} > F_{\alpha}(k, n-k-1)$.

where n is the number of sample groups and k is the number of independent variables

The results obtained are shown in table 5 and Fig. 6.

Table 5: Prediction effect test

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BP forecast	142636	144377	143948	143900.2	143582.1	141997.9	141642.4	140078.2	139606	139064.5
Literature prediction	144308	144384	144424	142852	143522	142930	142171	141780	140107	139678
F=1.332			$F_{\alpha}(N, n-k-1) = 2.18$			F<F_{α}			Regression effect is remarkable	

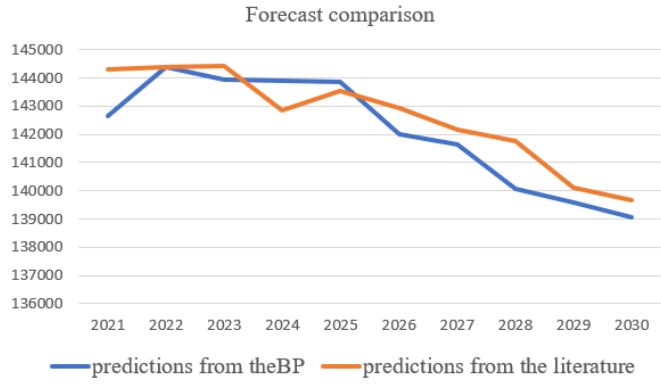

Figure 6: Measurement comparison chart

After calculation F=1.332, $F\ \alpha$ =2.08, $F < F\ \alpha$, the regression effect is significant. Therefore, it further illustrates the reliability and rationality of the model.

To ensure a single variable, data testing was performed with a sampling model. A(0.25, 0.25), the corresponding fertility willingness and fertility cost are both 0.5. On the basis of the original data, since the fertility growth rate β is 20.1%, the proportion of fertility willingness C1 at this time is 0.603, and the proportion of fertility cost C2 is 0.397. Connect the two points (0,0.603) and (0.397,0) to obtain a straight line tangent to the curve. B(0.16, 0.36) is obtained by calculation, as shown in Fig.7 and Fig. 8.

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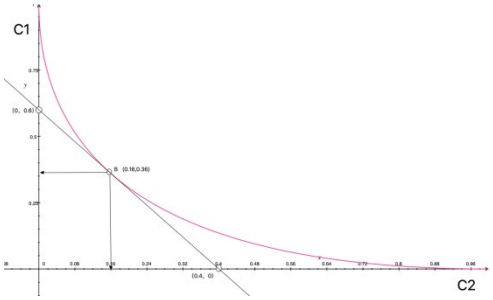

Figure 7: Under the effect of fertility growth rate, the weight of willingness of sample families

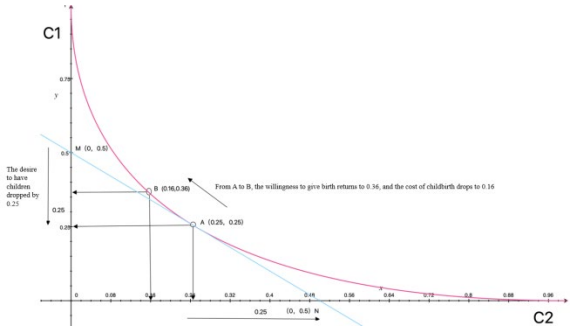

Figure 8: Changes in the sample under the effect of fertility growth rate

From the comparison of Fig. 7 and Fig.8, it can be clearly seen that after adding the state subsidy, the willingness to bear children increased from 0.25 to 0.36; the childbearing cost decreased from 0.25 to 0.16. Therefore, through the method of state subsidies, the willingness to bear children can be effectively improved and the cost of childbearing can be reduced. This result is also consistent with the actual situation, which further illustrates the reliability and rationality of the model.

5. Conclusion

Based on the data from the national bureau of Statistics of China and using the AHP, this paper constructs an index system of factors affecting family fertility costs. A total of four cost aspects of economy, willingness, manpower, and opportunity have been quantitatively analyzed. A mathematical model of the relationship between fertility cost and fertility willingness is established, and the numerical solution fits well with the actual curve, which can more accurately describe the inhibitory effect of fertility cost on fertility willingness.

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