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Neural Network Analysis of the Determinants of Happiness of Community Residents: Application of the Multi-Layer Perceptron Analysis Method

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Summary

This study is based on analysis of a questionnaire survey conducted in 2021 by the Center for Community Well-being Research at the Graduate School of Public Administration at Seoul National University in Korea, which targeted all local authority residents in Korea. The aim of this study is to identify the factors that affect the happiness level of local residents in Korea by means of an artificial neural network analysis. Few studies have been conducted that analyse the important factors which affect the happiness level of local residents in Korea using the artificial neural network multi-layer perceptron model. In this study, among artificial neural network analyses, relative importance analysis was conducted for independent variables, using the weight values for each node calculated via the multi-layer perceptron analysis method. It was found that the important factors affecting happiness levels were marital status, age, period of residence, income level, area of residence (urban or rural), religion, occupation type, residence type, gender and education level.

Keywords: neural network analysis, multi-layer perceptron, happiness research.

1 Introduction

The ultimate goal of human beings may be said to be happiness. It is no exaggeration to say that central government, local government and individuals aim ultimately to move towards the goal of happiness (Chanan, 2002; Lee and Kim, 2014; Kim and Lee, 2013; Murphy and Kuhn, 2006) . In particular, local authorities expend huge resources on increasing the happiness levels of local residents. Although it is not easy to define the concept of happiness exactly, because it is somewhat abstract, it is nevertheless possible to agree on a general description of it. 'Happiness' can be defined as a state in which humans feel subjective satisfaction with their lives (Kruger, 2010; Campbell, 1974). East and West, past and present, national and local government have made ceaseless efforts to increase the happiness levels of the people. However, it is difficult to increase the happiness levels of local residents all at once. Many international organizations such as the United Nations also publish reports each year measuring the happiness levels for individual countries. Against this background, many studies (Cuthill, 2002; Kee et al., 2014; Whorton and Moore, 1984; Tomaney, 2015; Wiseman, 2008) have been conducted which measure the happiness levels of residents at regional level, and at the same time analyse the determinants of happiness.

However, while many studies on happiness at the national level are still being conducted, not many are being conducted on happiness at regional level (OECD, 2014; Easterlin et al., 2010; Max-Neef, 1995; Morgan, 2004). In addition, many of the regional studies (OECD, 2014; Kusel, 1991; Ramsey and Smit, 2002; Morrison, 2011) have been affected by various problems regarding predicting the determinants that affect happiness levels, because they have used only traditional research methods. Recently, the need for research on happiness at the regional as opposed to the national level has increased (OECD, 2014; UN, 2022), and at the same time, research methods such as machine learning and big data analysis using artificial intelligence have to some extent been used in place of traditional research methods. However, methods such as machine learning have not yet been universalized. If a method such as machine learning is applied to the study of happiness levels, it is more advantageous to systematically ascertain the characteristics and patterns of the population to be studied as a whole.

In Korea, as in other countries, the need to study happiness at the local level is gradually increasing. There is ongoing interest, not only from an academic point of view but also from the policy point of view of local government, in what factors affect happiness and how these can be optimized. Nevertheless, as stated above, it is difficult to find a study that analyses the pattern and characteristics of happiness at regional level using big data analysis. Against this background, in this study the Community Well-Being Research Center of the Graduate School of Public Administration at Seoul National University used data collected by questionnaire, targeting all local authority residents in Korea in order to find out what factors may influence the happiness levels of local residents in Korea. Specifically, the study aimed to:

1. Analyse the factors that affect the happiness level of local residents in Korea.
2. Identify the relative importance of these factors.
3. Explore the possibility of applying neural network analysis to research on happiness.

2 Theoretical Discussion

Happiness includes various dimensions such as physical, mental and social satisfaction, and is not a temporary subjective emotion but a positive state related to overall life conditions (Kruger, 2010; White, 2008). Thus it can be said to include various aspects such as health, economy, welfare and social relationships. The condition of happiness may be felt at the national level, or by local residents at the community level. At community level, the positive state that local residents may experience regarding overall living conditions may be called happiness at the local level. The concept of community is applied in various ways. Small village communities and apartment complexes are also called communities, and the association between countries known as the European Community is also called a community. Today, a community formed in cyberspace is also called a community. However, from a sociological point of view, ‘community’ generally refers to a spatial unit in which community members share the same values (Murphy and Kuhn, 2006). Therefore, when it comes to community well-being, this may be seen in terms of a spatial unit that has a certain degree of unity in making judgements or recognition of well-being.

Similar concepts include quality of life, satisfaction, social well-being and public happiness. Conceptually, it is not easy to distinguish them; not only do they contain certain philosophical characteristics, but even if they are distinguished there may not be much practical benefit from a policy

point of view. Nevertheless, similar concepts will be defined here on the basis of existing studies, and the differences from the concept of happiness that they display briefly examined.

First, happiness may be said to be an overall emotional state related to joy or enjoyment (Christakopoulou et al., 2001), and is said to appear as a judgement result in determining quality of life (Lomas, 2017). Quality of life (QOL) is defined as the positive characteristics that appear in a wide range of areas that affect life (Parks et al., 2012).

In addition, life satisfaction may be defined as a state in which people feel good about choices or directions for the present or future (Rashid, 2015). Social happiness, on the other hand, is defined as a strong positive feeling in a relationship with family or friends (Riff, 1989), while public happiness is a concept that is opposed to private happiness, and relates to participation in the public sphere, that is, in national affairs. It is defined as the emotion one has in enacting a role (Seaton and Beaumont, 2015). Public happiness, therefore, has the opposite character to private happiness, which relates to the enjoyment or accumulation of wealth resulting from participation in private activities. Above, we instanced concepts similar to happiness. Although there is no clear difference between these concepts, the concept most commonly used in relation to local residents is 'happiness', which may be said to be one's overall subjective positive emotional state in daily life. It may truly be said that it is a part of life.

To date, studies on happiness at local level have mostly used traditional statistical methods (Kjell et al., 2016). Various traditional statistical methods carry out a hypothesis test on whether the calculated models are statistically significant, but if the model is not significant, a significant model must be found before proceeding with the subsequent steps. In this process, the predictive value of the model is low. In addition, traditional statistical analysis methods attempt to estimate the population via a sample group rather than target the whole population. Unlike traditional statistical analysis methods, however, the neural network analysis used in this study not only targets a lot of data, but also repeats the analysis process until a solution is found. In addition, It may prove a more useful analysis method in the future, because it can bring about high predictive power without being subject to statistical assumptions made by traditional statistical analysis.

3 Research Design

3.1 Data

The data used in this study are those that were collected by the Center for Community Well-Being at the Graduate School of Public Administration, Seoul National University by distributing questionnaires to residents in all local government areas in Korea. The survey was conducted between January and February 2021, and data were collected through face-to-face and online surveys against the background of Coronavirus. The total number of respondents was 16,555, and some missing data were excluded from the analysis.

3.2 Key variables

The dependent variable in this study is the level of 'happiness' of local residents. On a scale of 1 to 10, 10 means the highest level of happiness and 1 the lowest. The average happiness score for all respondents was 6.68. Therefore, in this study, a score of less than 6.68 was coded 1, and a score of 6.68 or more was coded 2.

A total of ten independent variables were used. These are described in Table 1.

Table 1 *Independent variables*

Variable	Variable abbreviation	Explanation	Remarks
gender	sex_1	1: male 2: female	
income level	incomelevel_1	1: low income level 2. high income level	1: Less than 4 million won (KRW) per month. 2: More than 4 million won (KRW) per month.
job type	jobtype_1	1: not a full-time worker 2. regular worker	1: Contingent workers are those who are unemployed or on temporary contracts.
education	education_1	1. less educated 2: highly educated	1: Less than high school graduation. 2: High school graduation or higher.
married	marriage_1	1: marital Status 2: divorce 3: unmarried 4: bereavement	
religion	religion_1	1: no religion 2: religious	
dwelling type	residence_1	1: I do not have my own home. 2: I have my own house.	
age	age_1	age	
residence	urban_1	1: rural areas 2: urban area	
length of residence in the area	livingyear_1	residence period	

3.3 Analysis method

In this study, neural network analysis is used. Neural network analysis is a technique that implements artificial intelligence through repetitive learning via a machine learning algorithm that mimics the neural cell mechanism of the human brain. In other words, it aims to create intelligence with mechanical modelling techniques, by mimicking chemical phenomena occurring between neurons on around 100 billion synapses in the human brain and synapses located at their ends. This method increases the predictive power of the dependent variable more than traditional statistical algorithms, and, unlike traditional statistical methods, it does not require the statistical assumptions that are necessary for model calculation. There are various types of neural network analysis. Broadly speaking, it may be divided into multi-layer perceptron (MLP) and radial basis function (tangerine) methods. In this study, multi-layer perceptron is used. The reason for this is that the MLP method involves the most basic algorithm of neural network analysis and has a strong ability to classify, discriminate and estimate.

4 Analysis Results

4.1 Basic structure of the artificial neural network model

The basic structure of the multi-layer perceptron model used in this paper is shown in Figure 1. This is a three-layer structure consisting of one input layer, one or more hidden layers

and one output layer. Each layer consists of nodes and processes data, and each node takes over the output value of the previous step and goes through an activation function to calculate the output value again. The artificial neural network goes through a process of adjusting the connection weights of nodes in a direction in which the error between the output value and the actual value is reduced, which is called learning. In this study, an optimal neural network model that was not overfitted was built through a total of 1,000 repetitions of learning.

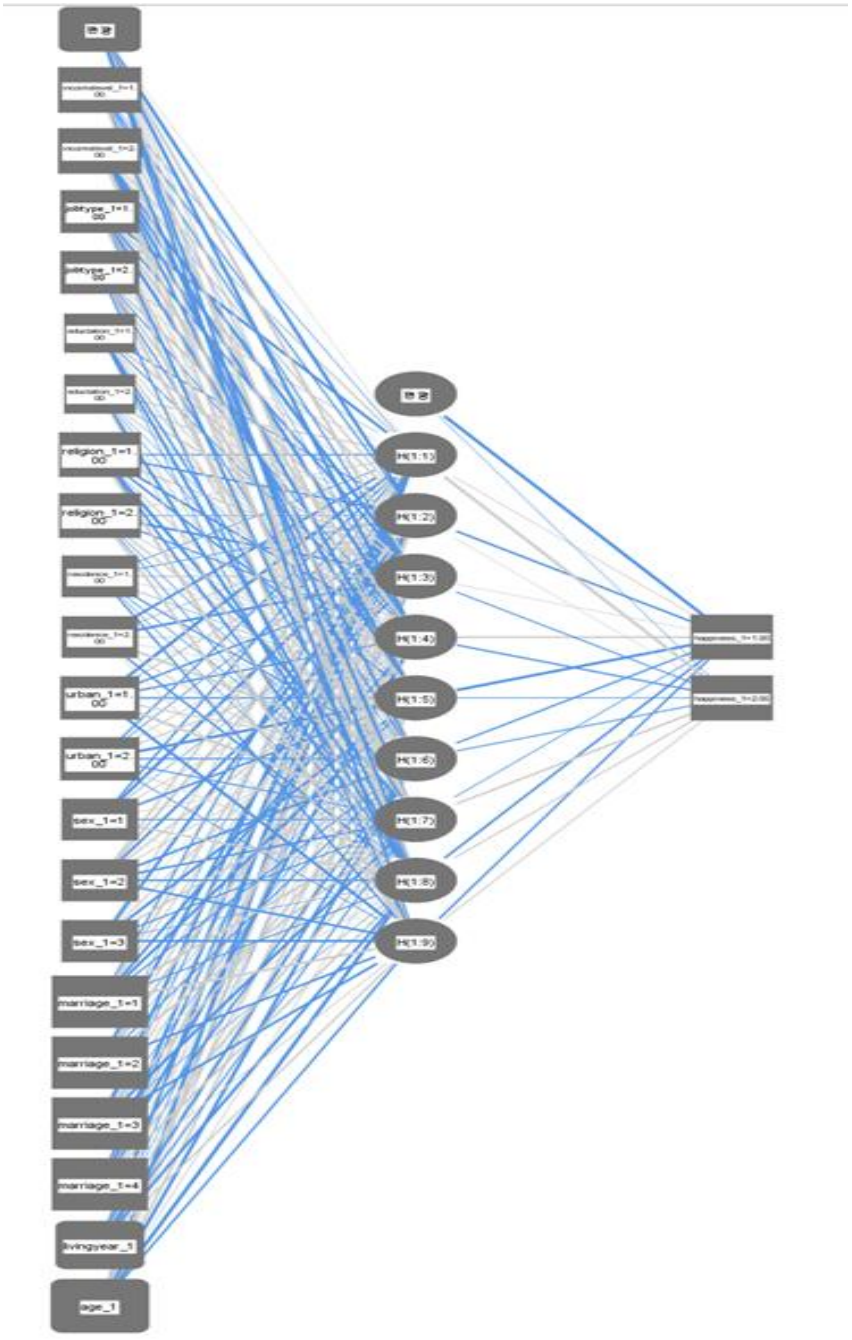

Figure 1 *Artificial neural network structure*

Meanwhile, the parameter estimation table (Table 2) is the result of selecting synapse weight values in the artificial neural network structure. The connection strength between the independent variable presented in Figure 1 and the hidden layer, and that between the hidden layer and the output layer, are calculated. Looking at the parameter estimates, it can be seen that marriage_1 has a large influence.

Table 2 *Parameter estimates*

		예측										
		은닉층 1									출력층	
예측자		H(1:1)	H(1:2)	H(1:3)	H(1:4)	H(1:5)	H(1:6)	H(1:7)	H(1:8)	H(1:9)	[happiness_1 =1.00]	[happiness_1 =2.00]
입력층	(편향)	-.021	-.551	.312	.550	-.150	.359	-.393	-.183	.013		
	[incomelevel_1=1.00]	.467	.138	-.152	-.339	-.425	-.482	-.078	-.513	-.333		
	[incomelevel_1=2.00]	-.321	-.291	.403	-.174	.318	.298	.419	.409	-.381		
	[jobtype_1=1.00]	.191	.447	.371	-.214	-.178	.173	.091	.507	-.452		
	[jobtype_1=2.00]	-.060	.121	.065	.059	-.166	-.029	-.008	-.438	-.138		
	[eductation_1=1.00]	.124	.252	.189	.314	-.279	.141	.328	.117	-.141		
	[eductation_1=2.00]	-.213	.326	-.188	.497	-.356	.526	-.020	.288	.070		
	[religion_1=1.00]	.061	.377	.421	.325	-.381	-.308	.047	.377	-.014		
	[religion_1=2.00]	-.223	-.221	.136	.220	-.265	-.307	-.323	-.172	.104		
	[residence_1=1.00]	-.248	.304	.236	.012	-.161	-.023	.353	.314	-.306		
	[residence_1=2.00]	-.141	-.336	-.391	.018	.186	-.307	-.337	-.480	.300		
	[urban_1=1.00]	-.083	-.322	-.274	-.176	.485	.178	.255	-.217	-.358		
	[urban_1=2.00]	.012	.059	-.185	-.013	.179	.000	.152	.452	-.026		
	[marriage_1=1]	-.289	-.398	-.562	.069	-.453	-.163	.335	.485	.434		
	[marriage_1=2]	-.014	-.311	.356	.629	.286	-.133	-.061	-.163	-.434		
	[marriage_1=3]	-.423	.181	-.263	.157	.322	-.628	-.105	.324	-.349		
	[marriage_1=4]	.207	-.086	-.492	-.026	.221	.287	.403	-.122	-.344		
	[sex_1=1]	.046	-.427	.301	.391	.499	-.085	.025	-.351	-.425		
	[sex_1=2]	.296	-.102	.015	.240	-.277	.130	.463	.282	-.202		
	[sex_1=3]	-.339	.071	.496	.197	.424	.244	-.432	-.319	-.267		
	age_1	.274	.049	-.296	-.335	-.141	-.026	-.616	.032	-.176		
	livingyear_1	.079	.240	-.206	-.588	.156	-.587	-.169	-.420	-.156		
은닉층 1	(편향)										-.493	-.045
	H(1:1)										.252	-.120
	H(1:2)										.350	-.234
	H(1:3)										.335	-.087
	H(1:4)										.774	-.001
	H(1:5)										-.025	-.184
	H(1:6)										-.332	.086
	H(1:7)										-.258	.231
	H(1:8)										-.110	-.407
	H(1:9)										.047	.176

4.2 Verification of the goodness of fit of the model

The applicability and power of the artificial neural network multilayer perceptron model used as the analysis model in this study were analysed. To test the suitability of the artificial neural network multilayer perceptron model, prediction accuracy, Receiver Operating Curve (ROC) analysis, was conducted. ROC analysis is a method for determining the suitability of the neural network model, and can be confirmed by AUROC (Area Under ROC), which is the result of plotting sensitivity on the Y axis and 1-specificity on the X axis. The AUROC criterion is classified as fail if AUROC is less than 0.6, poor if less than 0.7, fair if less than 0.8, good if less than 0.9, and excellent if less than 1.0. In this study, as Table 3 shows, it is 0.743, which is the FAIR level. Therefore, it appears that there is no major problem in terms of the adequacy of the model. Table 3 shows the ROC values.

Table 3 *ROC VALUE*

		AREA
happiness_1	1.00	.743
	2.00	.743

Figure 2 shows the predicted probability analysis result. In this graph, the x-axis is the value of happiness_1, the actual target variable, and the y-axis the probability value of the predicted outcome.

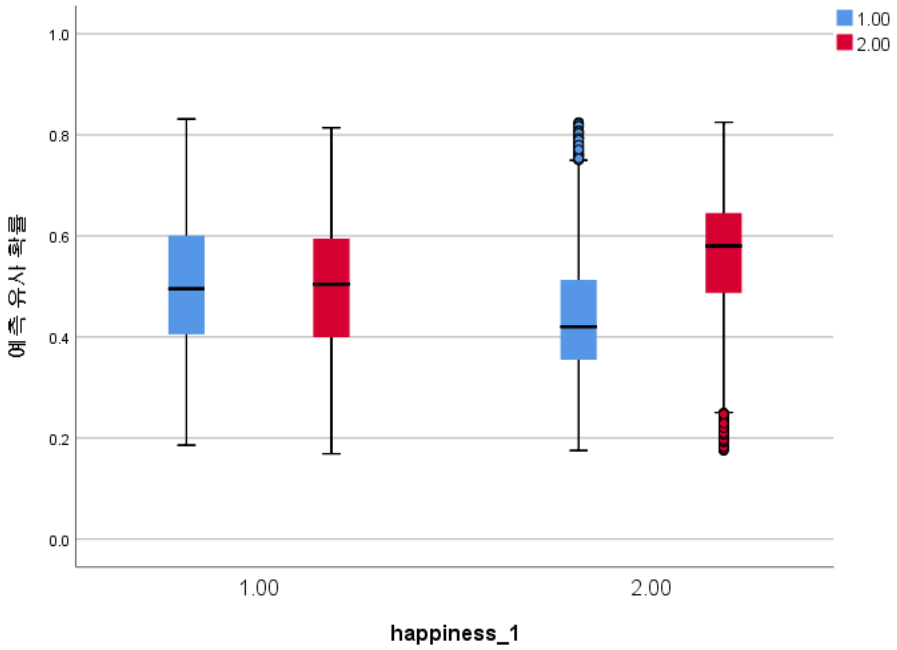

Figure 2 *Prediction probability chart*

Figure 3 shows the most important ROC curve results for the goodness-of-fit verification in this study. When the ROC graph shows a curve that rapidly increases and then mitigates, it can be evaluated that the model is well suited. Looking at Figure 3, we see that the goodness of fit is not very high, but as Table 3 indicates, the value of AUC is 0.743, which means that there is no problem with the goodness of fit of the model.

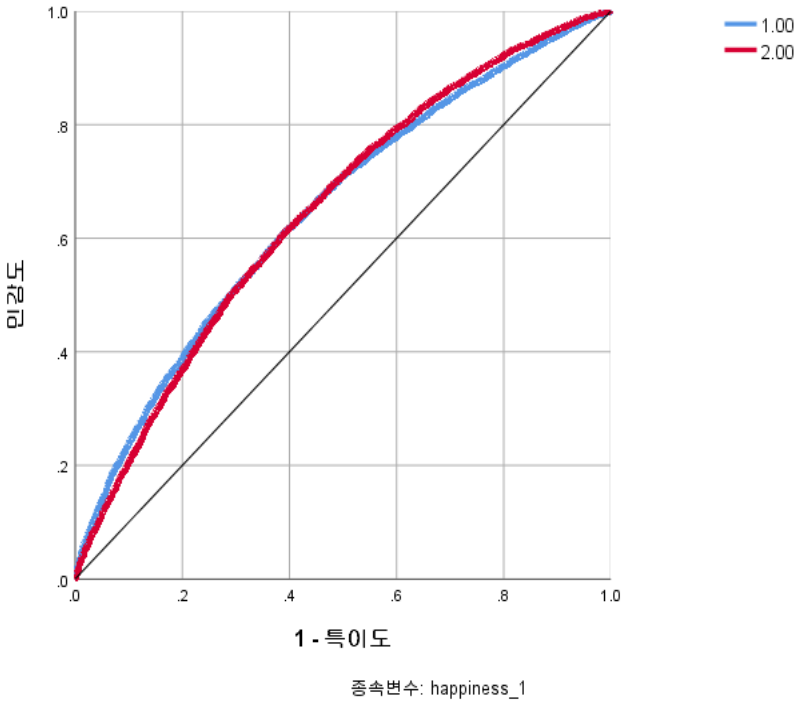

Figure 3 *ROC curve result*

Figure 4 shows the cumulative profit chart. Here, as well as in the ROC chart, the interpretation is that drawing a rapidly rising curve represents a better fit.

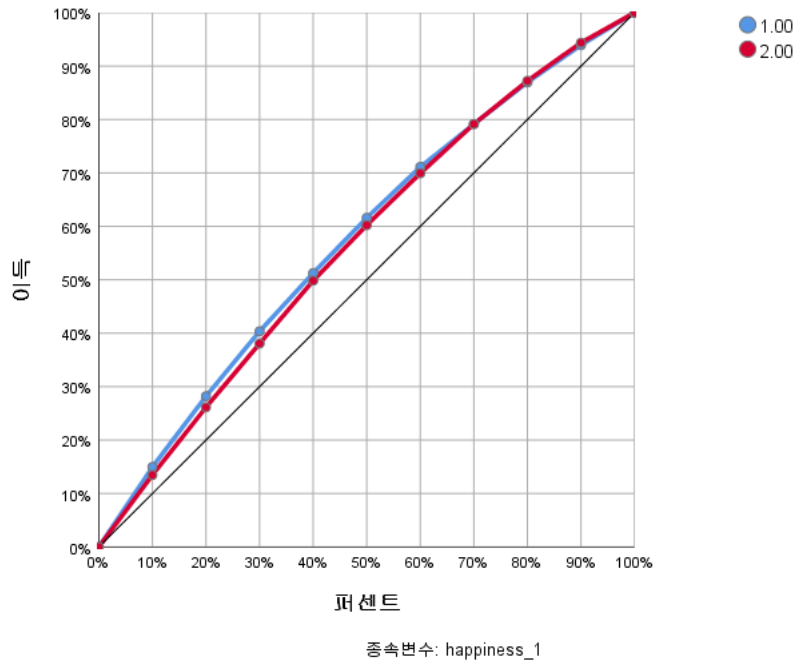

Figure 4 *Cumulative profit chart*

Figure 5 shows the lift diagram. Contrary to the above-mentioned cumulative profit plot, the lift plot is interpreted as having a better fit with a steeply declining curve. In general, the ROC chart is mainly used to verify the fit of the model, and the cumulative profit chart and lift chart are used as supplements. Together, these two figures suggest that the fit of the model is relatively good.

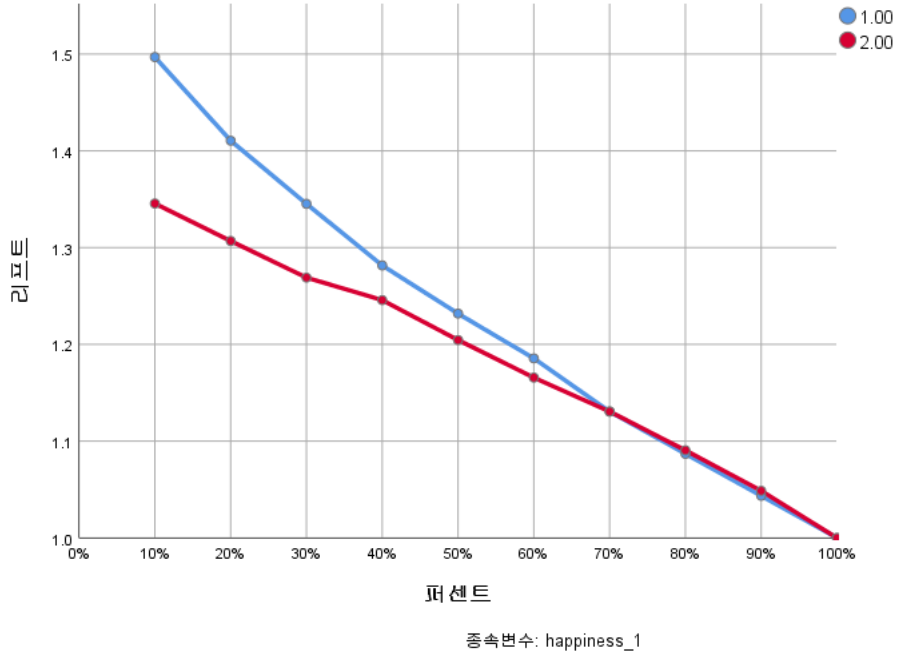

Figure 5 *Lift diagram*

4.3 Importance of the independent variables

Table 4 shows the relative importance of the independent variables that affect this happiness (happiness_1). Among the variables that affect happiness, marital status appears to have the greatest effect. In other words, married people have a higher level of happiness than

unmarried people. Next is the age variable: older people have higher levels of happiness than younger people.

Table 4 *Importance of independent variables*

	Weight	Normalized weight
incomelevel_1	.105	57.9%
jobtype_1	.065	36.0%
education_1	.029	16.0%
religion_1	.095	52.7%
residence_1	.055	30.5%
urban_1	.095	52.6%
sex_1	.085	47.2%
marriage_1	.181	100.0%
age_1	.166	91.9%
livingyear_1	.125	69.1%

Figure 6 shows the degree of influence of the independent variables on the dependent variable, level of happiness, in order. The variable that has the greatest influence on happiness, the dependent variable, is marriage, which means that a married person has a higher level of happiness than a non-married person. Assuming that the influence of the happiness level is 100, the next important variable is age, which has an influence of 91.9 per cent.

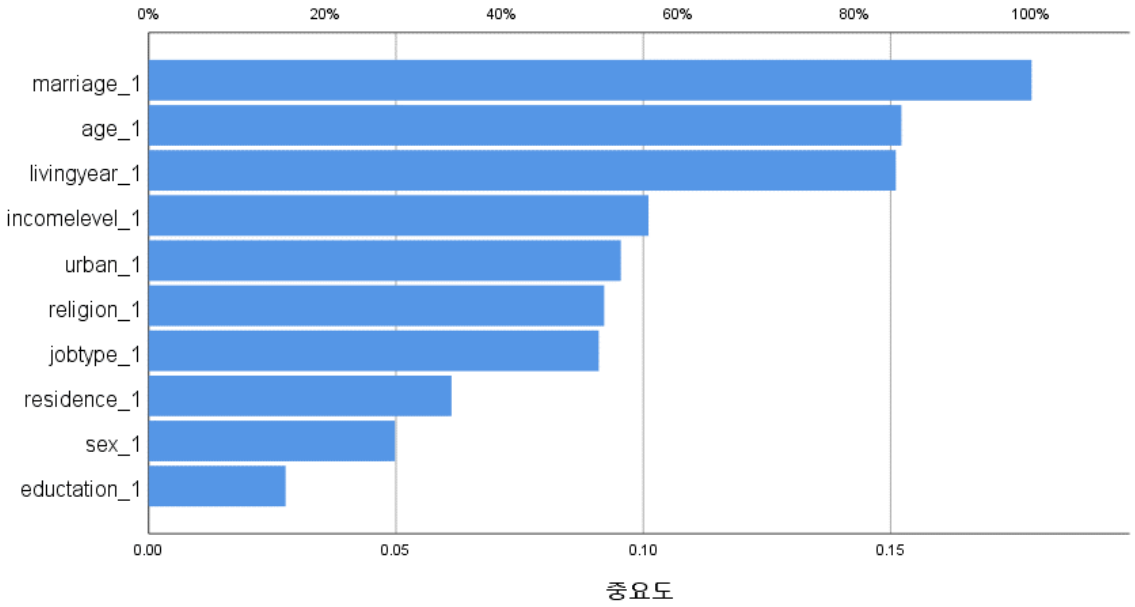

Figure 6 *Importance graph for independent variables*

5 Conclusion and Implications

This study analysed important factors that affect the happiness levels of local residents in Korea using an artificial neural network multi-layer perceptron model. For the weight value of each node calculated by the artificial neural network analysis, an importance analysis was performed using the weight division method. Important factors that affect the happiness level of local residents include: marital status, age, period of residence, income level, area of residence (urban/rural), religion, occupation type, residence type, gender, education level. The comprehensive analysis results and their implications may be summarized as follows.

First, the marital status of local residents has the greatest effect on their happiness levels. This means that married people have a higher level of happiness than single people or people living alone for other reasons. This has significant implications for Korean society in the future. Korea as of 2022 was a country with a low marriage rate among OECD countries, and in particular the birth rate was also at the lowest level. Looking at this trend, if we assume that the marriage rate will continue to decrease, there is a possibility that the happiness levels of local residents across the country will also decrease. Even though the Government cannot force people to get married, measures aimed at promoting marriage by identifying the causes of the low marriage rate are needed. In particular, in Korea, problems with children's education costs, house prices and childcare facilities for children are among the major factors that make young people hesitate to marry. The Government needs to recognize this issue and quickly establish short- and long-term measures to address it. In addition, not only central government but also local government should comprehensively establish and implement measures against the decline in the marriage and birth rates.

Second, it is necessary to recognize that the older the person, the higher the happiness level, and the lower the happiness level of younger residents. This implies that one reason younger people are unhappy is because they may feel that various conditions related to marriage, childbirth and child education after that are insufficient. This phenomenon may also be said to have a close correlation with the decrease in the marriage and birth rates. If the phenomenon becomes severe, conflict between generations may arise. In particular, recently, young people in Korea have harboured a lot of negative perceptions about the elderly. There is a strong tendency to think that they are taking away the jobs of the younger generation, even though they do not have the ability to do this, and their wage levels are higher than those of the younger generation even though their productivity is low.

However, there is something wrong with the perceptions of these young people. The high standard of living enjoyed in Korea today is possible because of the hard work of the baby boomers now in their fifties or older. It is necessary to recognize that middle-aged people in their fifties and older in Korea represent a generation who have been working silently while living through the most difficult times in Korean society. They are a generation who have made tremendous efforts to survive in a fiercely competitive society. The development of today's Korean society would not have been possible without the dedication of people now in their fifties and older. The Government and civic groups need to make an effort to foster this awareness among young people. In this context, there is a need to mobilize various methods to increase the happiness levels of young people.

Third, the unique contribution of this study consists in its having derived meaningful research results by analysing important factors affecting the happiness levels of local residents using a new methodological approach. Nevertheless, due to the black box characteristics of neural network analysis, it has a limitation in that it cannot provide a basis for causal relationships between variables and model calculation results. In this connection, it is necessary to identify the influencing relationship between important variables and dependent variables through complementary analysis such as logit model analysis. There is a need, in the future, to overcome the limitations of neural network analysis and to make predictions and classifications that can further increase accuracy.

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