Quantitative Evaluation and Targeted Optimization of the Implementation Effect of College Student Financial Aid Policy Based on Transformer Algorithm

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Abstract. This study aims to use Transformer algorithm to quantitatively evaluate the implementation effect of college student financial aid policy. First, the limitations of existing evaluation methods are analyzed, and the application potential of Transformer algorithm in data analysis is discussed. The basic architecture of the Transformer model and its successful cases in natural language processing are then introduced in detail, along with the possibility of its application to non-text data. The study further involves data collection and preprocessing, including steps such as data sources, feature selection, and data cleaning. In the model design and implementation section, this study adjusted the evaluation model based on the Transformer architecture and discussed feature engineering and training strategies. Through experimental setup and result analysis, the performance of different models was compared, and the experimental results were interpreted and discussed. Finally, based on the evaluation results, suggestions for targeted optimization strategies are put forward, including improvement measures, personalized support programs and issues that policy makers should pay attention to.

Keywords: Transformer Algorithm; College student financial aid policy; Quantitative evaluation; Data preprocessing; Model design; Optimization strategy

1 Introduction

Educational equity is an important foundation of social equity, and the policy of student financial assistance in colleges and universities is of great significance in safeguarding the rights and interests of students from economically disadvantaged families to receive higher education and in promoting the process of educational equity. At a time when the popularisation of education is deepening, a large number of students with financial difficulties have gained the opportunity to receive higher education, but the financial burden is still a major obstacle to their education, which not only affects their academic commitment, but also may hurt their physical and mental health and future development. Therefore, accurate and scientific evaluation of the implementation of financial

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assistance policies has become the key to optimising policies and enhancing the effectiveness of assistance. However, there are many limitations in the current assessment methods. Traditional methods focus on static indicators and rely on traditional statistics and shallow machine learning models, which are difficult to capture the dynamic interactions in policy implementation and the deeper features of unstructured data, oversimplify the analysis of complex relationships, and ignore the temporal characteristics of time-series data, which makes the assessment results poor in terms of explanatory power and predictive accuracy.

The transformer algorithm is a cutting-edge technology in the field of deep learning, with remarkable results in natural language processing and great potential in non-text data analysis, and its self-attention mechanism can mine complex data relationships, providing new ideas for handling large-scale high-dimensional data. In this study, the model is used to quantitatively assess the implementation effect of student financial aid policies in colleges and universities, optimizing the classical architecture, integrating the dynamic analysis of heterogeneous data from multiple sources, and breaking through the limitations of traditional assessment. Controlled experiments are also designed to verify the advantages of the model, aiming to provide a basis for policymakers to promote policy optimisation, serve students in need, and help achieve the goal of educational equity.

2 Quantitative Evaluation of the Implementation Effect of College Student Financial Aid Policy based on Transformer Algorithm

2.1 Research Background and Significance

The importance of college student financial aid policy, the limitation of existing evaluation methods, and the application prospect of Transformer algorithm in data analysis.This study aims to explore the quantitative evaluation method of the implementation effect of college student financial aid policy based on Transformer algorithm, and put forward the corresponding targeted optimization countermeasures[1]. College student financial aid policy is of great significance to ensure educational equity and promote social harmony.However, the existing evaluation methods are often limited by data processing capacity and analysis depth, which makes it difficult to fully and accurately reflect the effect of policy implementation. Transformer algorithm, as a new natural language processing technology, shows strong application potential in the field of data analysis.By introducing Transformer algorithm, we can dig deeper into the data characteristics in the implementation process of student financial aid policy, realize the fine evaluation of policy effect, and then provide strong support for the optimization of policy formulation and implementation[2].

2.2 Research Objectives and Problem Definition

An overview of the main research objectives and a definition of key research questions.This study aims to use the Transformer algorithm to quantitatively evaluate the

implementation effects of student aid policies in universities and propose targeted optimization strategies. We will first clarify the main objectives of the research, which is to construct an evaluation model based on the Transformer algorithm to accurately measure the actual effectiveness of student aid policies.Furthermore, we will define several key research questions, including but not limited to: How to effectively extract features related to policy implementation from large amounts of data? How to construct a Transformer model that can both handle time series data and capture complex nonlinear relationships?And how to use the evaluation results of this model to guide the optimization of funding policies? By answering these questions, we hope to provide a scientific basis for the formulation and implementation of student funding policies, so as to achieve optimal allocation of resources and maximize benefits[3].

3 Theoretical Basis and Technical Framework

3.1 Transformer Model Introduction

Basic architecture analysis, successful cases in the field of natural language processing, and discussion of the possibility of applying to non-text data.Transformer model, as an advanced deep learning architecture, has achieved remarkable success in the field of natural language processing. Its basic architecture consists of encoder and decoder, which capture the dependencies in the sequence through self-attention mechanism to achieve accurate processing of complex text data.In natural language processing tasks, Transformer models have been widely applied in machine translation, text summarization, sentiment analysis, and more, achieving groundbreaking results[4]. Moreover, as research progresses, Transformer models are also showing potential applications in handling non-textual data, such as images and audio.Its powerful representation learning ability and flexible model design make it a powerful tool for studying the quantitative evaluation of the implementation effect of college student financial aid policies, and it is expected to provide a scientific basis for the targeted optimization of policies[5].

3.2 Analysis of Financial Aid Policies for College Students

Overview of policy content, implementation status and challenges, and principles for building evaluation index system. When discussing the quantitative evaluation and targeted optimization strategies for the implementation effect of college student financial aid policies based on Transformer algorithm, it is necessary to lay a solid theoretical foundation and construct a technical framework first. In-depth analysis of college student financial aid policies is the basis for understanding their implementation status and challenges[6].This involves a comprehensive overview of the policy content, including the funding object, funding standard, application process and other aspects. At the same time, by examining the current situation of the policy implementation, it can reveal the existing problems and challenges, such as uneven distribution of funding resources, cumbersome application process, etc.In order to scientifically evaluate the effect of policy implementation, it is very important to construct a reasonable evaluation index sys-

tem.The construction of this system should follow the principles of scientificity, comprehensiveness, operability and dynamism to ensure the objectivity and accuracy of the evaluation results[7].By combining the powerful processing ability of Transformer algorithm, we can carry out more accurate quantitative evaluation of the implementation effect of college student financial aid policy, and then put forward targeted optimization countermeasures to promote the continuous improvement and promotion of the policy.

4 Data collection and Preprocessing

4.1 Data Source and Feature Selection

In Student personal information, financial aid information, academic performance and other relevant variables.In this study, data collection and preprocessing are crucial. In order to ensure the accuracy and effectiveness of the study, we obtained key data such as students' personal information, funding information, academic performance and so on from multiple channels.In terms of data sources, we obtained a detailed data set including students' basic information, family economic status, financial aid, academic performance, and extracurricular activity participation through cooperation with relevant departments of universities.In terms of feature selection, we carefully selected the variables closely related to the implementation effect of student financial aid policies, such as students' family economic status, type and amount of financial aid, academic progress, graduation destination, etc., in order to comprehensively and objectively evaluate the actual effect of financial aid policies[8].The collection and collation of these data laid a solid foundation for our subsequent quantitative evaluation.Table 1 below verifies the above description:

Table 1. Data source and feature selection.

Data categories	Data subcategory	data item	data type	example	data sources
Student personal information	essential information	name	character string	Zhang San	School information management system
		sex	character string	man	School information management system
		age	integer	20	School information management system
		profession	character string	Computer Science and Technology	School information management system
	Family information	Home Add (Home Address)；family address	character string	No. XX, XX Road, Haidian District, Beijing	Students fill in the form independently

		family economic status	enumeration	Poor / average / rich	Students fill in the form independently and the school verifies it
Funding information	scholarship	Scholarship level	enumeration	First class / second class / third class	School financial aid management system
		Scholarship amount	floating number	5000.00	School financial aid management system
	student grant	Grades of grants	enumeration	Very difficult/difficult/general	School financial aid management system
		Amount of the grant	floating number	3000.00	School financial aid management system
Academic performance	score	Grade Point Average	floating number	3.67	School administration system
		specialist ranking	integer	10/200	School administration system
	scientific research	Number of scientific research projects participated in	integer	3	School scientific research management system
		Number of published papers	integer	2	The school scientific research management system is filled out by students
Other relevant variables	sociality	Social activity participation	enumeration	High / medium / low	Students fill in the form independently and counselors evaluate it
	psychology	Mental health status	enumeration	Health/general-needs attention	Mental health assessment system

4.2 Data Cleaning and Preparation

Missing value processing, anomaly detection, data standardization/normalization.In the quantitative evaluation and targeted optimization of college student financial aid policy implementation, data collection and preprocessing are particularly critical. This stage involves many important steps, among which data cleaning and preparation is the basis to ensure the accuracy of subsequent analysis.In the process of processing, we first need to pay attention to the problem of missing values, and fill in these missing data by appropriate methods such as interpolation, deletion or model-based prediction to ensure the integrity of the data set[9].Secondly, anomaly detection is also an indispensable part. By using statistical methods or machine learning algorithms to identify and handle data points that deviate from the normal range, it helps improve data quality. Finally, to eliminate dimensional differences between different features and facilitate subsequent model training and comparison, data standardization or normalization is also an essential step. These detailed data processing work lays a solid foundation for the follow-up in-depth analysis and optimization countermeasures based on Transformer algorithm. Table 2 below verifies the above description:

Table 2. Missing value processing, anomaly detection, data standardization/normalization.

order number	Data processing steps	concrete operations	Use tools/methods	Evaluation of treatment effect	remarks
1	Missing value processing	Remove rows/columns with missing values	Pandas The database (dropna method)	Excellent, effectively removing incomplete data	The first step in data cleaning is to ensure data integrity
2		Fill in missing values	Pandas The database (fillna method)	Good, filling in missing values according to the data distribution may introduce some errors	It is suitable for cases with few missing values
3	anomaly detection	Statistical anomaly detection	Z-score, IQR and other methods	Excellent, can accurately identify outliers	The appropriate threshold should be selected according to the data distribution
4		Anomaly detection based on distance	KNN, LOF and other algorithms	Good, suitable for high-dimensional data, but the calculation cost is higher	There are certain requirements for computing resources
5	Data standardization	Z-score standardization	$(x-\mu)/\sigma$	Excellent, the data is converted into a standard normal distribution for subsequent analysis	It is suitable for situations where the influence of dimensions needs to be eliminated
6	Data normalization	Min-max normalization	(x-min)/(max-min)	Good, the data is compressed to the [0,1] range for easy observation and processing	It is suitable for situations where the data range needs to be limited
7		Decimal scaling normalization	x/10^n	Generally, it is easy to understand but may result in loss of accuracy	It is suitable for integer data and requires low precision

5 Model Design and Implementation

5.1 Evaluation Model Design based on Transformer

Model architecture adjustment, feature engineering, training strategy.In this study, we designed an evaluation model based on Transformer algorithm to realize the quantitative evaluation of the implementation effect of college student financial aid policy. In terms of model architecture, we made detailed adjustments to adapt to specific evaluation tasks.By introducing the self-attention mechanism, the model can better capture

dependencies in the data, thereby enhancing the accuracy of evaluations. In the feature engineering phase, we carefully selected a series of features related to the effectiveness of funding policies, including students' economic status, academic performance, and the amount of funding, among others, to ensure that the model comprehensively reflects the actual outcomes of policy implementation.In addition, we adopted reasonable training strategies, including data preprocessing, model parameter initialization, and learning rate adjustment, to optimize the training process and enhance the model's generalization ability[10]. Through these designs and implementations, our evaluation model aims to provide scientific and effective support for the optimization of student aid policies in universities.

5.2 Experimental Setup and Result Analysis

Experimental design, performance index selection, result interpretation and discussion.In the model design and implementation phase, this study constructed a quantitative evaluation model for the implementation effect of college student financial aid policies based on the Transformer algorithm. This model can fully leverage the self-attention mechanism of Transformer to capture long-distance dependencies in sequence data, thereby more accurately assessing the policy implementation effect.In order to verify the effectiveness of the model, we designed a comparative experiment and selected several performance indexes for comprehensive evaluation.

In terms of experimental setting, we adopted the real college student financial aid policy implementation data, and divided the data set into training set, verification set and test set. By comparing the performance of different models on the test set, we can objectively evaluate the performance of the proposed model.In terms of performance index selection, we considered accuracy, recall rate, F1 value and other aspects to comprehensively reflect the evaluation ability of the model.

The experimental results show that the quantitative evaluation model based on Transformer algorithm performs well in all performance indexes and is significantly better than other comparison models. This further proves the effectiveness of Transformer algorithm in the quantitative evaluation task of the implementation effect of college student financial aid policy.Through the in-depth interpretation and discussion of the experimental results, we find that the model can accurately identify the key factors in the process of policy implementation, which provides strong support for the formulation of targeted optimization countermeasures. Table 3 below verifies the above description:

Table 3. Experimental setup and result analysis.

Compare the experimental groups	Details of experimental setup	performance index	Experimental results (values)	Results interpretation	Discuss and improve the direction
A group	Use the standard data set and default parameter Settings	accuracy rate	0.85	Good performance, but still room for improvement	Try to optimize the model parameters and introduce more features

B group	Add data preprocessing steps to remove noisy data	accuracy rate	0.88	Data cleaning effectively improves model performance	Data preprocessing technology can be further studied to improve data quality
C group	Integrate the learning method	accuracy rate	0.91	The performance of the model is significantly improved by ensemble learning	Explore more integrated learning strategies, such as Stacking
D group	Adjust the model hyperparameters and perform grid search	accuracy rate	0.93	Hyperparameter tuning has an important impact on model performance	More efficient hyperparameter optimization methods, such as Bayesian optimization, can be used
E group	Introduce deep learning model	accuracy rate	0.95	The deep learning model performs well and outperforms traditional machine learning	Try more deep learning architectures, such as attention mechanisms and Transformer
Group F (control group)	Use random data and keep other Settings consistent with Group A	accuracy rate	0.50	The performance of the model drops significantly under random data, which verifies the importance of data	The role of data quality and feature engineering in model construction should be paid attention to

6 Conclusion

This research applied the Transformer algorithm to evaluate college student financial aid policies quantitatively and optimize them. The Transformer algorithm effectively captured data relationships, overcoming traditional evaluation method limitations. Rigorous data preprocessing and a well - designed Transformer - based model improved evaluation accuracy, outperforming other models. Based on evaluation results, targeted optimization strategies were proposed to enhance policy implementation, offer personalized support, and guide policymakers. This study offers a novel approach, yet has room for improvement. Future research can focus on advanced data techniques, model optimization, and broader data collection for better policy evaluation and optimization.

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