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Enhancing Product Quality in Cross-Border E-Commerce with AI and Big Data

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Enhancing Product Quality in Cross-Border E-Commerce with AI and Big Data

Improving product quality is crucial for CBEC companies. Good quality products can reduce return rate and increase companies’ revenue.

This thesis summarized methods to improve product quality from two questionnaires and semi-structured interviews. Quantitative, qualitative research methods and big data analytics (BDA) methods were adopted. From the perspective of supply chain experts and international customers, a model of innovative methods to improve quality was formed. This model is centered around five elements of supply chain management (SCM), quality management tools (QMT), artificial intelligence (AI) technology, CBEC and customer needs.

Using AI technology and quality tools throughout the supply chain can improve product quality and reduce defect rates. By predicting the needs of international customers through BDA, problems can be discovered in advance and customized services can be provided. The method of improving product quality studied in this thesis can bring reference and guidance value to CBEC companies.

Keywords:

cross-border e-commerce (CBEC), supply chain management (SCM), quality management tools (QMT), artificial intelligence (AI), big data analytics (BDA).

Content

1. Introduction 7

1.1 The subject of this thesis 7

1.2 The objectives of this thesis 8

1.3 Methodologies and tools 10

1.3.1 Questionnaire methods and purpose 10

1.3.2 Semi-structured interview 12

1.3.3 Analyzing tools 13

1.4 The frame of the research 13

2. Background of CBEC, SCM, QM, AI and customers' need 14

2.1 Cross-border e-commerce (CBEC) 14

2.2 Supply chain management (SCM) 15

2.3 Quality definition and quality management (QM) 16

2.4 Customers' need 18

2.5 AI technology and big data analytics (BDA) 19

Big data analytics (BDA) 21

Random Forest 23

3. Questionnaire 1 25

3.1 The process of collecting questionnaire 1 26

3.2 Sample Size 27

3.3 The answers of the 18 multiple-choice questions 28

3.4 Reliability, validity analysis, hypothesis analysis and correlation analysis 34

3.5 Analysis of open questions 41

3.6 The conclusion of questionnaire 1 44

4. Questionnaire 2 45

4.1 The process of collecting questionnaire 2 46

4.2 Sample Size 46

4.3 Qualitative analysis of the answers of 20 questions in questionnaire 2 47

4.4 Big data analytics of the questionnaire 2 54

4.5 Summary of questionnaire 2 57

5. Semi-structured interview summary 58
6. Discussion 61
Limitation 63
Future 63
Conclusion 64
Reference 66

Appendices

Appendix 1: Questionnaire 1
Appendix 2: Questionnaire 2
Appendix 3: Cover letter for procurement and supply chain experts
Appendix 4: Cover letter for international customers
Appendix 5: The first ten cleaned and sorted data

Figures

Figure 1: The core process chart 9
Figure 2: The principal diagram of random forest 24
Figure 3: Statistical results of Q1 answers 29
Figure 4: Statistical results of Q2 answers 29
Figure 5: Statistical results of Q3 answers 30
Figure 6: Statistical results of Q4 answers 30
Figure 7: Statistical results of Q6, Q8, Q10, Q12, Q13 and Q15 answers 32
Figure 8: Statistical results of Q5, Q7, Q9 and Q11 answers 33
Figure 9: Statistical results of Q16, Q17, Q18 and Q19 answers 34
Figure 10: Relationship map from Q16-Q19 41
Figure 11: The advantages of AI from the respondents' perspective 42

Figure 12: The disadvantages of AI from the respondents' perspective 42
Figure 13: The distribution of Q1', Q2' and Q4' 48
Figure 14: The distribution of Q5' 49
Figure 15: The distribution of Q7' 50
Figure 16: The answers of Q6', Q8', and Q9' 51
Figure 17: The answers of Q10' 52
Figure 18: The answers of Q11', Q12', Q14', Q15' and Q16' 52
Figure 19: The answers of Q13', Q17', Q18', Q19' and Q20' 53
Figure 20: The correlation heatmap 55

Table

Table 1: the specific feedback situation on questionnaire 1 28
Table 2: Specific quality tools from respondents 34
Table 3: Result of item-total statistics 36
Table 4: Total variance explained 37
Table 5: Multiple logistic regression parameter estimates 39
Table 6: Bayes factor inference on pairwise correlations from Q16-Q19 40
Table 7: Quality improvement suggestions from respondents 43
Table 8: the specific feedback situation on questionnaire 2 47
Table 9: The distribution of Q3' 48
Table 10: The random forest regression model 56
Table 11: The mean square error and accuracy 57
Table 12: The sales table of ten products in March 2024 from one Chinese CBEC company 59

List of abbreviations

AI	Artificial Intelligence
ASPICE	Automotive Software Process Improvement Capability Determination
ASTM	American Society for Testing and Materials
BDA	Big Data Analytics
BMC	Baseboard Manager Controller
CA65	California 65
CBEC	Cross-border E-commerce
CE	Conformity European
CIPS	Chartered Institute of Purchasing and Supply
CPC	Cost-per-click
CPSIA	Consumer Product Safety Improvement Act
ERP	Enterprise Resource Planning
FCC	Federal Communications Commission
FMEA	Failure Modes and Effects Analysis
GS	Germany Safety
IoT	Internet of Things
ISO	International Organization of Standardization
JIT	Just-in-time
KMO	Kaiser–Meyer–Olkin
KNN	K-Nearest Neighbor
LLM	Large Language Models
LSS	Lean Six Sigma
NLP	Natural Language Processing
PDCA	Plan Do Check Act
QM	Quality Management

QMT	Quality Management Tool
QT	Quality Tool
REACH	Registration Evaluation Authorization and Restriction of Chemical
ROHS	Restriction of Hazardous Substances
SAP	System Application and Products
SC	Supply Chain
SCM	Supply Chain Management
SMART	Specific, Measurable, Achievable, Relevant, and Time-Bound
SPSS	Statistical Product and Service Solutions
SWOT	Strengths Weaknesses Opportunities and Threats
TQM	Total Quality Management
UL	Underwriter Laboratories

1. Introduction

1.1 The subject of this thesis

As China becomes more and more internationalized, the third "Belt and Road" International Cooperation Summit Forum held in October 2023 in Beijing, the capital of China. H.E. Xi Jinping emphasized that China supports one open world economy. China will build Silk Road e-commerce cooperation pilot zones and sign free trade agreements and investment protection treaties with more countries (Xi, 2023). This theme advocated "Silk Road E-commerce", which further promotes the development of China's cross-border e-commerce (CBEC). With the background of such favorable national policies, Chinese enterprises catch this important opportunity to enhance existing CBEC platforms. However, according to customs statistics, Chinese CBEC imports and exports in 2022 were 270 billion euros, of which exports were 200 billion euros, but the comprehensive return rate was about 10% (Jiang & Guo, 2023). Therefore, it is crucial to improve the quality of CBEC platforms, which can not only reduce the economic losses caused by returns for enterprises, but also improve customer satisfaction. This thesis aims to improve product quality by studying the application of artificial intelligence (AI) technology in supply chain management (SCM) and big data analytics (BDA) of international customer needs. This provides Chinese CBEC companies with practical guidance on how to improve product quality.

There are more than 13000 articles to investigate the relationship between AI, CBEC, SCM, quality management (QM) and customers in Google Scholar. However, most articles did not comprehensively describe the relationship between the above five, and they only included keywords related to two or three of the above five. I combine all these five keywords in a comprehensive and

detailed way to analyze the contribution of AI technology to SCM, improvement of quality and customer demand satisfaction in the field of CBEC. Therefore, the perspective of this thesis is innovative.

1.2 The objectives of this thesis

Guo and Zhang (2022) pointed out that CBEC had become a crucial way to "open new way trading". BDA can assist CBEC sellers in selecting high-demand products with good quality that meet customer needs. BDA is also an excellent tool to improve supply chain management (SCM) and customer service (Alrumiah & Hadwan, 2021). Chinese companies can improve their market share and increase their revenues through using AI technology. Moreover, this can fundamentally solve the problem of international returns and exchanges for customers and reduce the negative review rate of CBEC platforms.

In addition, to win credibility and reputation among consumers all over the world, and to increase customer confidence and company revenue, the Chinese companies need high-quality products and excellent service. Companies need artificial intelligent customer service that responds quickly and can answer flexible and personalized questions. Firstly, quality management needs to be monitored from the source of the supply chain (SC) through AI technology and quality tools (QT) to ensure that the quality of the products meets international quality standards (ISO). Secondly, it is necessary to ensure that the product packaging is safe during international logistics and transportation and complies with the size and packaging rules of third-party overseas warehousing. Finally, the BDA method is used to analyze the trend analysis of international customers' overall quality satisfaction with products purchased on the CBEC platform. The CBEC platforms are an intermediate link and bridge to collect product issues from customers and classify these issues. If there are internal issues within the company, such as poor customer service, which will be made

continuous improvements and adjustments within the company. If they are supply chain problems, these quality problems will be fed back to the supply chain. Then the SC should develop strategies to continuously optimize and improve the quality of all aspects of products, such as adjusting materials, optimizing packaging, improving product performance, reducing costs, etc. This forms a closed-loop process between customers as the core and continuous quality improvement. I created a core model based on the 5 elements (SC, QM, AI, CBEC and customers' need), as shown in Figure 1.

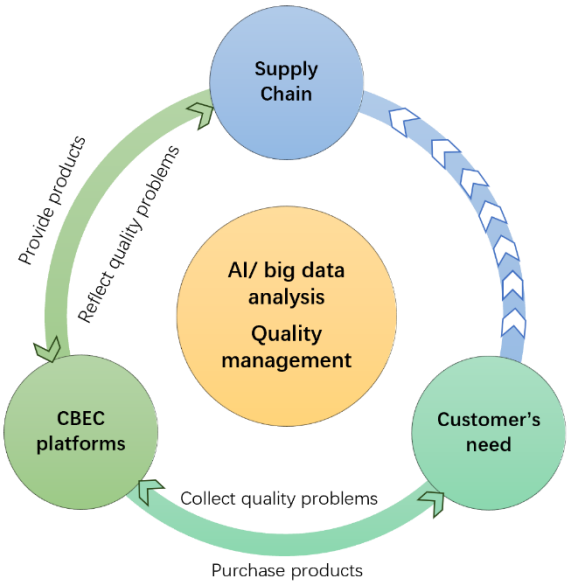

Figure 1: The core process chart

I hope the chart of Figure 1 can be the core model for CBEC companies to improve the quality of products and satisfy the customers. Thus, CBEC companies can reduce the rate of return and increase their revenue. In addition, the mainly purpose of this thesis is to solve the following three problems:

1. How can AI technology and quality tools optimize supply chain management and better improve product quality?
2. How to analyze customer satisfaction trends through BDA and identify

problems in advance to improve product quality and service issues?

3. Will products developed using big data and AI software be more likely to have good sales and increase revenue for the company, under the context that CBEC platforms are in a stage of rapid development?

1.3 Methodologies and tools

This study adopts quantitative and qualitative research methods and semi-structured interviews. These methodologies can specifically answer the above three questions.

1.3.1 Questionnaire methods and purpose

I designed two different web-based questionnaires. These two questionnaires do not involve sensitive topics, such as gender, marriage and other private and controversial issues. Both questionnaires are anonymous and confidential. Moreover, these two questionnaires are distributed to the investigators in the form of website links through a reputed online survey Webropol platform, which provides accessibility and data protection.

Questionnaire 1 is about AI and quality management technology empowering supply chain management. There are 20 questions, which include two open questions. This questionnaire adopted the descriptive statistics and inferential statistics quantitative analysis (DATAtab, 2024). Qualitative method (Pritha, 2023) was used to analyze the two open questions. Descriptive method was used to analyze the basic information of the respondents. These charts can provide more visual data. The age distribution, occupation status, industry and professional level of the respondents can be clearly counted. In this way, the professionalism of the information obtained from this questionnaire can be guaranteed. Hypothetical methods in inferential statistics are used to analyze

the relationship between the use of AI technology in various aspects of the supply chain and the improvement of efficiency and product quality. From this, it can be deduced whether AI technology can improve the work efficiency and product quality of each link in the supply chain. Pearson correlation analysis is used to analyze the relationship between the use of quality tools and improving product quality standards. It can thus be concluded whether quality management tools can improve product quality. Finally, qualitative methods were used to count the answers to the two open-ended questions. Expert advice from respondents can generate new ideas and creative insights.

Questionnaire 2 is about analyzing the purchasing behavior of international customers on CBEC platforms. The survey also included 19 multiple choice questions and one salary fill-in-the-blank question (considering different currency units). This questionnaire adopted not only qualitative analysis, but also big data analytics (BDA) (Tableau, n.d.). Although the number of the questionnaire 2 returned was only 103, BDA can also be used to predict the satisfaction of international customers. By mastering the specific model application of BDA, CBEC company can better predict popular products. In this way, CBEC backend sales data and customer evaluation data can be exported and used for BDA. This can help the company make better and more effective product selections. At the same time, through the predictive customer evaluation system, the companies can better understand product defects or service deficiencies. The company can adjust its strategy accordingly based on the forecast results. Quality issues can be fed back to suppliers or factories for product quality improvement and control. For service issues, internal personnel training within the company can be strengthened. For packaging defects, the packaging can be reinforced and tested for safety. This can improve the praise rate of the company's CBEC platform. This in turn increases the company's sales and revenue.

Since this thesis focuses on the five core elements of SCM, AI technology, QM, CBEC, customer demand and satisfaction, it forms a closed-loop process from quality feedback to quality improvement. Therefore, two questionnaires were designed. One was based on supply chain and quality management, and the other was based on the purchasing behavior of international customers on CBEC platforms. The purpose of the first questionnaire is whether AI technology and QT have been used in all aspects of the supply chain from the perspective of procurement supply chain experts. Whether AI technology and QT have improved the efficiency of each link in the supply chain. Where they have improved product quality and reduced product defects rate. The purpose of designing the second questionnaire is to understand the purchasing behavior on CBEC platforms and the degree of satisfaction with product quality and services from international customers. This forms a closed-loop chain from how to improve production efficiency and quality at the source to the end customer's experience and feedback on product quality.

1.3.2 Semi-structured interview

In addition to the two questionnaire survey methods introduced above, this thesis also uses a semi-structured interview method (George, 2023). I interviewed a purchasing manager, who has worked in CBEC industry for 9 years. I mainly communicated with her by sending messages. Her company's products are primarily sold on Amazon. Hot-selling products and competitive products will be analyzed through SellerSprite (Sellersprite, n.d.), a software based on big data and AI technology. Products developed through this AI software are usually profitable. She provided me with ten specific products to analyze. At the same time, I asked her about their company’s product returns and product quality control. Specific analysis results are presented in Chapter 5.

1.3.3 Analyzing tools

The two questionnaires followed the quantitative and qualitative research methods. Quantitative research method contains descriptive research statistical and inferential statistical analysis through SPSS statistics, such as frequency, general description, Bayesian statistics, regression, graphical method, correlation analysis, hypothesis analysis, etc. (Barinderjit et al., 2022). In addition, the BDA method was used to analyze and test the reliability of international customers' purchase intentions and return and exchange trends on the CBEC platform based on supervised learning deep learning algorithms (Guo & Zhang, 2022). The Random Forest Model was used to build the sample model and calculate the accuracy of target variable in the Python. The international customers' satisfaction with the products on CBEC platforms is the target variable. For an introduction to the concepts and principles of deep learning and random forest model, see Chapter 2.5.

1.4 The frame of the research

First, I need to design two questionnaires based on the core content of this thesis. Then I discussed completing these two questionnaires with my mentors. Second, I sent the two surveys separately to the target groups. I need to reward them for receiving enough surveys whenever possible. Third, I compiled the answers to these surveys. The two questionnaires are analyzed separately. Fourth, I conducted a semi-structured interview with a purchasing manager, who has worked in CBEC industry for 9 years. Then I analyze her company's product sales data. Finally, I make a discussion and conclusion.

2. Background of CBEC, SCM, QM, AI and customers' need

2.1 Cross-border e-commerce (CBEC)

China's cross-border e-commerce is developing rapidly with the development of Industry 4.0, which includes advanced technologies (Internet of Things, artificial intelligence, BDA, smart machines, etc.) and more efficient and flexible supply chain 4.0 (Khan, 2023). With the continuous advancement of Silk Road e-commerce, so far, China has signed bilateral e-commerce cooperation agreements with 30 countries. China's partners span five continents, becoming an innovation point in economic and trade cooperation (Department of E-Commerce of the Ministry of Commerce Article, 2019). China's CBEC has more than 1,500 overseas warehouses with a total area of more than 19 million square meters, providing strong support for the development of e-commerce (Information Office of the Ministry of Commerce Article, 2023). With the increase in online shopping around the world, it helps international customers have a more convenient way to shop.

China's international CBEC B2C platforms include Amazon, eBay, AliExpress, Wish, Lazada, Shopee, Alibaba, DHgate, LightInTheBox, SHEIN, Banggood, Gearbest, Temu, TikTok, etc. These e-commerce trades have made traditional trade methods easy and increased economic turnover efficiency. Moreover, they have declined trade costs and played a strong role in inspiring the development of international trade (He & Xu, 2018). A recent study by Li, (2021) concluded that although the world has been under lockdown since the outbreak of Covid-19 in 2019, sales on CBEC platforms have grown rapidly. According to customs statistics, in 2020, China's CBEC import and export volume increased by

31.1%, reaching 220 billion euros, far exceeding the 1.9% of national foreign trade in the same period.

As far as we know, China CBEC is in the development of its life cycle and broad prospect of future development. Although competition in CBEC is fierce, including price, brand, product variety, logistics, innovation, AI, and high-tech competition, it is still in a blue ocean market. If new Chinese enterprises enter the CBEC platform currently. They can consider continuous innovation and optimization in an intelligent, green, diversified, and global approach to satisfy consumer needs and market changes (Asset Information Network, 2023).

2.2 Supply chain management (SCM)

SCM includes planning, procurement, manufacturing, delivery and returns. The plan is the advance planning of the links in the entire supply chain. It is a clear mind map that guides the orderly progress of the steps in each link. With the development of Industry 4.0, AI technology has already penetrated SCM in recent years and has brought immeasurable value to SCM (Dash et al., 2019). Deep learning algorithms, digital data, AI-enhanced logistics robots, AI-enhanced camera equipment robots, machine language, etc. have been widely used in all aspects of the supply chain. Through the mature application of AI technology, customer needs can be accurately analyzed and collected to achieve customer customization. Procurement can use ERP systems and BDA to calculate market trends and product price trends, better plan, and control inventory, and optimize the entire procurement process. The goal is to save more capital costs for the enterprise. Production and manufacturing can use AI robots to perform more precise manufacturing, achieve zero errors, and save labor costs. However, according to the development trend of Industry 5.0, the future is not for robots to replace humans, but for humans and robots to live in harmony and develop together (Frederico, 2021). International logistics in the

field of CBEC can provide customers with faster and more accurate logistics services through the using of AI skills and can sort packages with zero errors and transport packages safely in accordance with packaging specifications. Customers will receive more comprehensive information from robot customer service. Although the AI robot is not flexible enough, it will accurately extract keywords to respond to questions.

MBAlib (2022) emphasized that SCM is customer-centered, emphasizing the core competitiveness of the enterprise, the win-win concept of mutual collaboration and optimizing information flow as the fulcrum, which can quickly respond to customer needs. Through the collaborative cooperation of all links in the supply chain, the company's costs can be reduced. The company's core competitiveness and customer satisfaction can be improved. Better services can be provided to customers. In the process of supply chain optimization management, QMT also plays an important role. The application of QMT and continuous improvement tools can enable the supply chain manufacturing links to produce zero-defect, quality-free products. Such products can reduce the return rate of products on CBEC platforms and reduce losses caused by product problems for enterprises. Moreover, risk management tools can also predict in advance, avoid, and mitigate risks for the entire supply chain.

2.3 Quality definition and quality management (QM)

The definition of quality no longer simply refers to product quality, but also includes service quality, process quality and work quality. In the field of CBEC, quality not only refers to product quality, but also includes product description quality on the platform, packaging and transportation quality, customer service quality and delivery timeliness quality, etc. Quality simply means meeting and exceeding customer expectations (Dosland, 2019). To achieve quality that meets customer needs, it must comply with ISO quality standards. This also

requires the use of quality management tools (QMT). Effective and correct use of QMT can comprehensively improve everything from the source of production to process quality and then to the service quality of each link.

In the era of Industry 4.0, tools such as smart machines, smart factories, BDA, ERP systems, and AI can help optimize processes, improve production efficiency, and resource allocation. Sensors can be used at each production stage to minimize quality problems and the cost of quality. Industry 4.0 provides solid support for the successful implementation of total quality management (TQM) principles (Sader, 2019). TQM takes customer as the core. It emphasizes doing it right at first time. It needs continuous improvement. Quality is attitude. It needs to keep, train and educate all employees to participate, providing a good place to work, encouraging teamwork, and improving customer's satisfaction (Naidu et al., 2006). The application of TQM in SCM plays a very important role. SCM can apply the 8 principles of TQM (customer needs, leadership, employee participation, process management, system management, continuous improvement, correct decision-making, maintaining good relationships with suppliers). It implements complete quality control and quality guarantee. And at the same time improve product quality. And meet all quality standard specifications, namely ISO 9000:2015 (Paswan, 2020).

Using Lean tools in SCM can reduce waste in industrial production, including waste in production processes and unused employee creativity. Griffiths (2022) concluded that Lean as a concept should be practiced by all involved in the supply chain, both in terms of planning and analysis. Lean manufacturing tools facilitate continuous improvements in production efficiency and product or service quality. Lean tools include Kaizen, Poke Yoke, Kanban, Just in Time, PDCA cycle, SMART Goals, Root Cause Analysis, Ishikawa Diagram, 5S, 7Wastes, etc. The superimposed use of these tools can improve production efficiency, zero defects, prevent errors, and avoid waste and economic losses in

the continuous improvement of the supply chain and risk management.

Another powerful conceptual tool is six sigma, which is used in SCM to achieve continuous improvement and find out the causes of errors in the process. Using statistical and non-statistical tools and techniques, variability and bias in the production process can be addressed to achieve higher satisfaction for customers and maximize economic benefits for the organization (Skalli et al., 2023). Six Sigma can eliminate the defect of product through using DMAIC (Design, Measure, Analyze, Improve and Control) method. It can ensure the quality of products from the source of supply chain.

The combination of Lean and six sigma, namely LSS tools, is a very powerful tool in continuous improvement. As a comprehensive approach, LSS focuses on not only removing redundant and useless activities, but also eliminating process defects. Hence, it can make organizations achieve their aims and satisfy customers (Tanjuakio, 2024). Coupled with the implementation of TQM, the quality of factory production can ensure zero defects, and can provide the most reliable products for CBEC platforms, greatly exceeding customers' expectations for quality satisfaction.

2.4 Customers’ need

From the CBEC platforms’ analysis, the increasing sales reflect strong customer demand for online shopping. Lu et al. (2021) pointed out purchase intention has become an important indicator for predicting consumer behavior. The questionnaire is used to understand the real needs of customers, the degree of pursuit of quality, satisfaction with the CBEC shopping experience. Then BDA is used to analyze the customer's shopping behavior and intentions. In this way, companies can customize products according to customer needs and truly create a customer-centered and quality-oriented attitude to achieve a win-win

scenario for the supply chain organization and society.

Studying the needs of market customers is the first step for every enterprise to produce new products. Companies can use big data analytical technology to extract products that customers demand or summarize quality issues reported by customers and feed these data back to suppliers. The SC where the supplier is located can produce new products or improve product quality and service according to the needs of the purchaser. They also can do their best to ensure that customers are 100% satisfied with product quality and service. This forms a closed-loop quality management system with the supply chain described above. The entire system is said to be centered around the CBEC platform, supply chain management and customer needs. AI and big data analytical technology are the core to connect the entire system flexibly. And this system can help enterprises reduce losses caused by quality defects and maximize corporate profits.

2.5 AI technology and big data analytics (BDA)

The core technology around this thesis is AI technology and BDA. Next, the application of AI technology in supply chain management (SCM) is introduced and how to use big data to analyze sample questionnaires is stated.

The application of AI technology in SCM

As mentioned above, in the era of supply chain management 4.0 and 5.0, the application of AI in SCM is more extensive. What is AI? AI is the process of simulating human intelligence using computer systems or machine languages (Laskowski & Tucci, 2024). Its working principle is to train a large amount of labeled data and analyze the correlation and type of data. Then it forms a memory. It can learn, reason, self-correct and creative, so that it can make intelligent predictions about future trends and form expert systems.

AI is the most used in procurement systems, such as various intelligent ERPs, which can improve the work efficiency of procurement personnel and reduce the error rate caused by manual labor. These intelligent systems can link inventory and sales systems, monitor inventory levels, and help procurement make timely stock replenishment decisions. They are also linked to the financial system and can monitor financial payment information and view unpaid and paid information in a timely manner. At the same time, it can be connected to the supplier system, which can record and track whether the supplier information is completed. It can play a role in preliminary risk control of suppliers. It also makes transactions between the company and suppliers more transparent, cooperation more coordinated, and mutually beneficial. AI can assist purchasing personnel to directly issue purchasing instructions for materials with low value and oversupply in SWOT. AI can intelligently manage inventory based on historical purchase records and sales records, and can optimize inventory based on maximum monthly, quarterly or annual demand to avoid out-of-stock or excessive inventory taking up space and funds. AI can predict raw material supply and production conditions. It can predict whether the supply of international raw materials will be timely or interrupted based on wars and natural disasters around the world. It helps purchasers have enough time to stock up in advance or find alternatives. AI can also be used to track cargo logistics and transportation information, so that purchasers and customers can know the arrival status of goods in real time. They can identify early whether shipments are delayed and make timely remedial measures. AI can also help drivers plan the best driving route and avoid roads with high traffic according to the risk level of the goods, which can better protect the goods and accidents that endanger innocent passers-by.

As Inbound Logistics (2023) mentioned, AI can also be used in conjunction with the Internet of Things (IoT) to foresee the visibility of the entire SC. For

example, data from manufacturers, logistics and transportation, natural disasters, accidents, weather forecasts, etc. can be combined, and predictions can be made after AI processing. And the risks can be avoided. AI can perform quality control. For example, the Amazon fulfillment center, one of the largest CBEC platforms, can use AI imaging stations to automatically identify defective products and then transfer them to staff for careful inspection, providing manual inspection and packaging efficiency. AI can also improve customer service, using large language models (LLM) to allow salespeople to understand customers' unique needs faster and provide personalized package services, thereby improving customer service satisfaction.

Based on the above information, I designed 20 questions in questionnaire 1: AI and quality management technology empowering supply chain management. Through these questions, I can learn about the application of AI in the supply chain, improve efficiency, use of quality management tools and improve product quality from the perspective of Chinese procurement experts, supply chain experts and other experts. So that I can make a rational and reliable analysis based on the answers to questionnaire 1. This specific analysis can be seen in Chapter 3.

Big data analytics (BDA)

BDA is the process of collecting, examining, processing, and using machine language models to analyze data to find market regulation, insights, patterns and trends. This benefit companies to make good decisions (Sedkaoui & Khelfaoui, 2020). Quickly obtaining the latest data and using BDA can allow companies to make more flexible decisions and be more competitive and sustainable in the market.

BDA has a wide range of applications and can help companies improve

marketing capabilities in different fields, reduce operating costs, quickly capture potential customers, and improve customer satisfaction. BDA can also develop products for the company. By analyzing sales data, it can intelligently analyze which categories of products are more popular in the market, so that the company can more accurately select, design, develop and purchase products.

BDA can also perform descriptive analysis, diagnostic analysis, prescriptive analysis and predictive analysis. Among them, predictive analysis can use machine language models for trend analysis. Machine language models are created by using labeled data, unlabeled data, or a mixed training algorithm of both, including four main machine algorithms: supervised learning, unsupervised learning, semi-supervised learning and reinforcement learning. Classification models for BDA mainly include logistic regression, naive Bayes, decision trees, random forests, K-nearest neighbors (KNN) and support vector machines (Vora & Bhatia, 2023).

After learning about BDA, questionnaire 2 was designed. Questionnaire 2 is mainly composed of descriptive multiple-choice questions. BDA can be used to analyze what kind of age, income and industry international customers have. What categories of products will they buy. Which CBEC platform will they choose. What will they describe the characteristics of the website, product functions, key trends in ratings and product satisfaction. The random forest regression model will be used to analyze the trend of international customer satisfaction with CBEC products.

In addition, the reason why I chose the random forest model regression was because I studied data engineering and AI technology courses. I analyzed the training of potential customers who would deposit money in the bank. Logistic regression, K-nearest neighbor, decision tree and random forest were compared. It was found that the accuracy of random forest was relatively higher.

Therefore, when analyzing Questionnaire 2, the random forest model was used to analyze the relationship and trend between each vector and variable.

Random Forest

Random forest is an integrated supervised learning method composed of multiple decision trees for classification, regression and other tasks. The more trees the forest contains, the stronger the forest is, which can correct the problem of overfitting of the decision tree to the training set, and the higher the accuracy of the algorithm (Donges & Whitfield, 2024). The random forest algorithm is a bagging integrated learning model based on decision trees. Its modeling can be divided into three steps (Simplilearn, 2023):

Step 1: The original data set is randomly sampled to obtain N sample training subsets.

Step 2: N sample subsets are trained to obtain corresponding weak learner models.

Step 3: The algorithm weights and votes the N weak learner models obtained by training to form a new strong learner, and finally output the result.

As shown in Figure 2, multiple decision tree models with different structures constitute a random forest, and when the model is output, the final output category will be determined by weighting and voting. This also fully reflects the advantages of the bagging ensemble model, which improves the generalization ability of the model through "average".

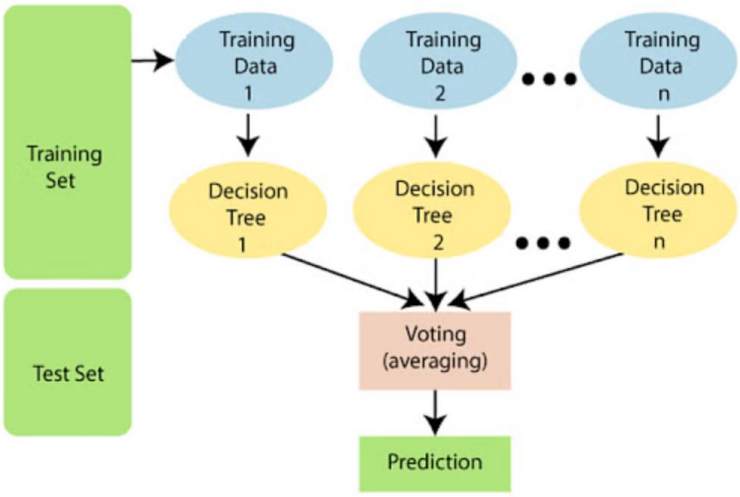

Figure 2: The principal diagram of random forest (Simplilearn, 2023).

After understanding the basic algorithm of random forest, questionnaire 2 will be imported into python for descriptive data analysis and random forest model analysis. Then the important hyperparameters in random forests are briefly introduced. The use of hyperparameters can enhance model performance and prediction capabilities. Hyperparameters that improve prediction capabilities include n_estimators, max_features, max_depth, min_samples_leaf, min_samples_split, max_samples, max_leaf_nodes, criteria and bootstrap. Hyperparameters that improve speed include n_jobs, random_state and oob_score (Sruthi, 2024).

When using sklearn function code in Python, some or all the above hyperparameters will be used in random forest regression. The hyperparameters can make the model more complete and achieve higher accuracy. Basically, I have introduced the concept, principles, algorithm formulas and hyperparameters of random forest. The specific methods and tools are introduced in Chapter 4.

3. Questionnaire 1

Questionnaire 1 included 20 questions. It mainly involved that Chinese procurement experts describe whether every link of supply chain uses AI technology or not and how many the improving efficient. Whether supply chain uses quality management tools or not, and if they have risk management awareness and prevention measurements. In addition, there are two open questions about what benefits or disadvantages do you think AI technology brings to supply chain management? Why? And what suggestions do they have for improving product quality. The specific questions are seen in Appendix 1. The 20 questions are showed as follows:

Q1: Your age

Q2: Your industry

Q3: Your job

Q4: Do you have CIPS (Chartered Institute of Purchasing and Supply) certification?

Q5: Does your company's procurement system use a digital intelligent platform for full-chain procurement collaborative management (such as SAP, Zhichubao, NLP, ERP and other intelligent systems)?

Q6: You think the intelligent procurement platform has improved procurement efficiency, reduced procurement costs and optimized supplier management.

Q7: Does the manufacturer or supplier you contacted use artificial intelligence AI technology?

Q8: You think that AI technology improves product quality and production efficiency in terms of quality control, preventive maintenance and intelligent production line optimization.

Q9: Does your industry's warehouse inventory management use artificial intelligence systems?

Q10: You think artificial intelligence technology improves warehousing automation, demand forecasting and supply planning.

Q11: Does the logistics and transportation in your industry use artificial intelligence AI

technology or the Internet of Things?

Q12: You think artificial intelligence and IoT combine to improve supply chain management efficiency.

Q13: You think supply chain management driven by AI technology improves product performance and decline scrap rate.

Q14: What benefits or disadvantages do you think AI technology brings to supply chain management? Why?

Q15: You strongly recommend that the entire supply chain ecosystem management system uses AI technology.

Q16: Does your industry's supply chain management system use Lean tools for continuous quality improvement? If yes, what kind of lean tools?

Q17: Does your industry's supply chain management system use Six Sigma tools for continuous quality improvement? If yes, what is the specific method?

Q18: Does supply chain management in your industry have risk management awareness and corresponding preventive measures? If yes, what kind of preventive measures?

Q19: Do your company's products meet the following product quality standards using quality management tools? For example, CPC certification, EN71, FCC certification, ASTM F963, CPSIA (HR4040), CE certification, UL certification, GS certification, ROHS testing and other standards? If yes, what standards are there?

Q20: What suggestions do you have for improving product quality (e.g. in terms of product performance, service life, reliability, safety, economy, applicability, appearance quality, service quality, work quality and scrap rate)?

3.1 The process of collecting questionnaire 1

The purpose of this thesis is to investigate the quality of products made in China on CBEC platforms. The respondents of questionnaire 1 are procurement supply chain experts and other experts from China. The publishing channels are mainly for a procurement expert group with 483 CIPS students. CIPS (Indeed, 2023) here refers to the Chartered Institute of Procurement and Supply, which is also the world's most authoritative procurement professional education

certification agency. Generally, most of procurement and supply chain professionals from companies across China has been to Shanghai CIPS training institution for more advanced and systematic training on relevant procurement and supply chain knowledge. The Level 4, Level 5 or Level 6 certificate obtained through the CIPS examination is recognized by the Chartered Institute of Procurement and Supply. Moreover, students who pass the CIPS examination have the corresponding level of professional purchasing and supply knowledge. I sent the link of questionnaire 1 to this procurement expert group on 27 January 2024. In addition, I wrote the cover letter and put it in the head of questionnaire 1, see appendix 3. The members of the group didn't take the initiative to answer these questions at first. After I sent Chinese traditional red envelopes with petty cash several times in the WeChat group, 59 of them successfully submitted the questionnaire. Due to their professionalism and integrity, the answers to these 59 questionnaires are reliable.

Then I also sent the link of questionnaire 1 to a procurement resource exchange group with 79 people. They have a better understanding of suppliers, procurement, logistics, inventory and quality management. I received 45 surveys from them. The last one survey was from an interviewer, who is purchasing manager working in a Chinese CBEC company. As of March 17, 105 surveys have been received. Sample size is analyzed below.

3.2 Sample Size

A total of 341 respondents opened the link. 137 respondents answered the question. A total of 105 respondents finally received feedback on questionnaire 1, with an answer rate of 76%. The specific feedback situation is shown in Table 1 below. It can calculate sample size according to the equation (Wallstreetmojo et al. 2024):

$$n = N \times \frac{\frac{z^2 \times p(1-p)}{d^2}}{[N-1+\frac{z^2 \times p(1-p)}{d^2}]}, \quad (1)$$

Where

N is population size, which equals to 562 (483+79).

z is a value in the normal distribution, which is 1.96 in case of 95% confidence level.

p is the percentage, which is generally 0.5.

d is error margin.

In the case of n=105 respondents the error margin is about 10%.

Table 1: the specific feedback situation on questionnaire 1

	Total	
	(N)	%
Submitted responses: Public weblink	105	76
Survey opened by respondents	341	248
Started responding	137	100

3.3 The answers of the 18 multiple-choice questions

These surveys have quite highly professional answers to analyze the relationship between supply chain, quality tools and quality. The specific statistics of the answers to the 18 multiple-choice questions are shown below.

The analysis of respondent's profile of Q1, Q2, Q3 and Q4

The demographic survey mainly includes their age, industry, position and CIPS level. To ensure the professional knowledge level of the topic, participants must

have work experience.

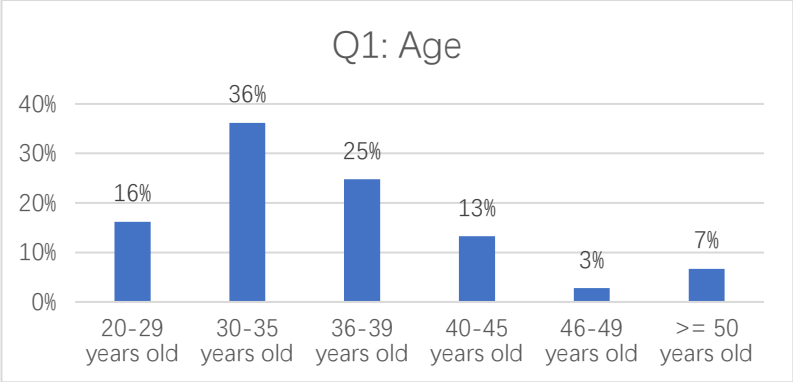

Figure 3: Statistical results of Q1 answers

From Figure 3, most of the respondents are between 30 and 35 years old (36%) and 36 to 39 years old (25%). That is, more than 60% are between 30 and 39 years old. It can show that they have considerable work experience.

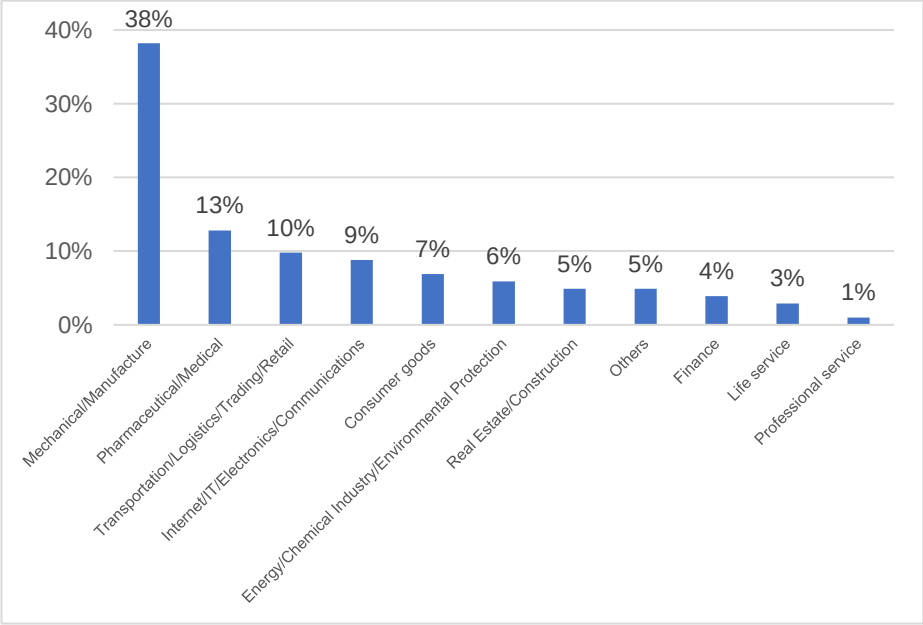

Figure 4: Statistical results of Q2 answers

From Figure 4, the study covers a wide range of industries, with machinery/manufacturing dominating at 38%. Pharmaceutical/Medical industry accounts for 13%, ranking second. Transportation/Logistics/Trading/Retail rank

third, accounting 10%.

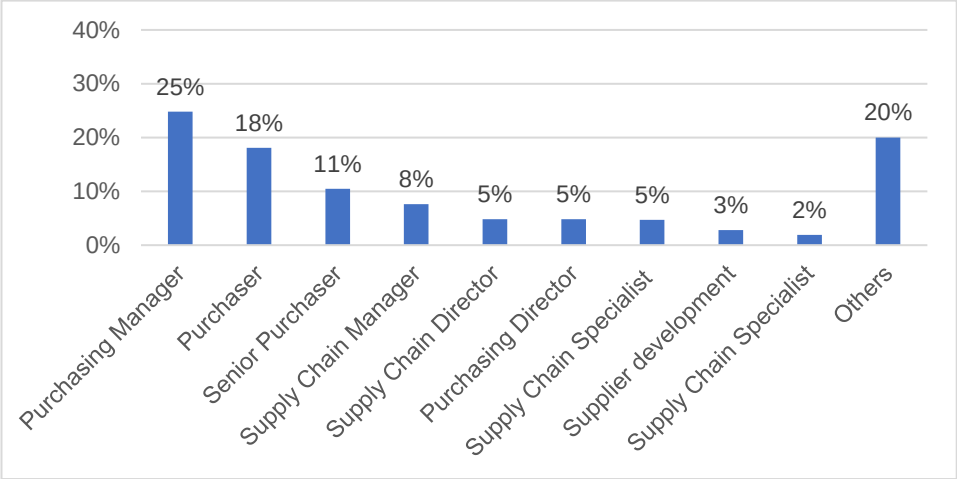

Figure 5: Statistical results of Q3 answers

It can be seen from Figure 5 that among the survey respondents, the position with the highest proportion is procurement manager, accounting for a total of 80% in terms of the number of procurement and supply chain experts.

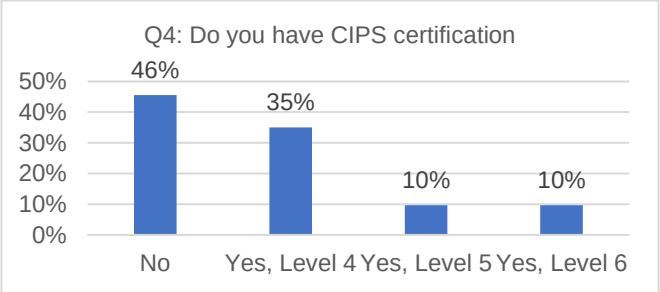

Figure 6: Statistical results of Q4 answers

From Figure 6, the total proportion of them who have received CIPS procurement professional training and obtained certificate level 4, level 5 and level 6 exceeds 50%.

It can be concluded from the above data that the analysis of the results of these answers has certain professional reference value. After all, based on the above basic demographic information of the respondents, it is also necessary to

conduct a comprehensive and thorough analysis of the remaining 16 questions. These 16 questions were from the respondent's perspective. They involved the use of AI technology, improvements in efficiency, use of quality management tools and improvements in quality throughout the supply chain.

Statistics analysis of survey results from Q6, Q8, Q10, Q12, Q13 and Q15

As can be seen from Figure 7, the survey respondents believe that AI technology can improve the efficiency of every link in the supply chain. Almost 30% of them choose the efficiency improvement percentage of 21%-30%. 53% of them remain neutral on the suggested use of AI technology in the supply chain. 25% of respondents somewhat agree and 11% of them completely agree with the suggested use of AI technology in the SCM. In conclusion, supply chain procurement experts believe that AI technology has improved the efficiency of each link in the supply chain to a certain extent. And 36% of them agree that AI technology should be used in the SCM. While 53% of them keep a neutral attitude on AI technology. The reasons can be concluded from the following analysis of whether the industries they are engaged in use AI technology in various aspects of the supply chain. In addition, the hypothesis testing method is used to verify the relationship between the use of AI technology and the efficiency improvement in supply chain.

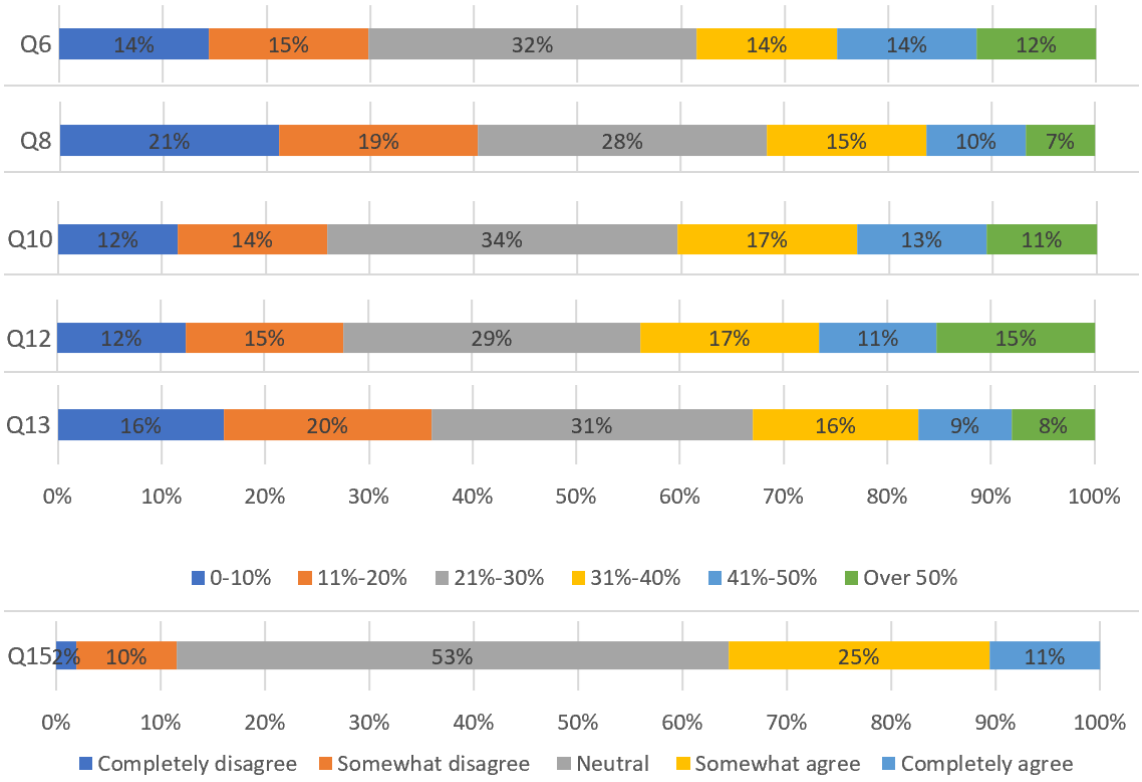

Figure 7: Statistical results of Q6, Q8, Q10, Q12, Q13 and Q15 answers

Statistical analysis of Q5, Q7, Q9 and Q11 on AI usage

Whether AI technology is used in each link of the supply chain or not. Figure 8 shows answers from 84 supply chain experts and 21 experts in other positions. Supply chain links include procurement departments, manufacturers/suppliers, warehouse inventory management, and transportation/IoT. From their responses, it is clear the proportion of the procurement department using AI technology is the most, which is 79%. And comparing the other three departments, manufacturers/suppliers use the minimal AI technology, the proportion is 38%. About 43% of respondents answer their industry's warehousing inventory management use AI technology. In addition, nearly half respondents think transportation/IoT use AI technology. From the above information, it can be concluded that AI technology is involved in each link of supply chain. Especially in the procurement department, the usage rate is the

highest.

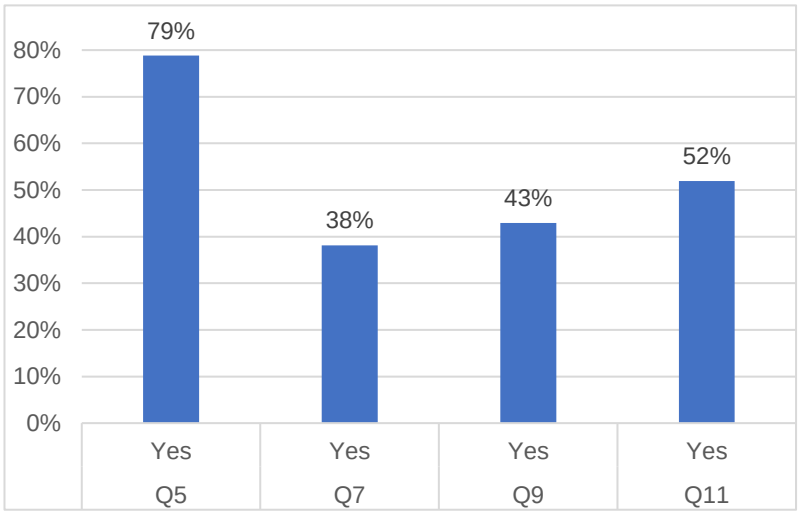

Figure 8: Statistical results of Q5, Q7, Q9 and Q11 answers

Statistical analysis of Q16-Q19 on quality tools usage

From Figure 9, it can be seen the frequency of Lean tools and Six Sigma tools by the respondents in the corresponding industries is relatively small. And the usage rates are only 38% and 33%. And 51% of their companies have risk management awareness and corresponding preventive measures. Another 49% of the respondents expressed that their company's products have reached corresponding product quality standards through using quality management tools. From these data, it can be concluded that the improvement of product quality is related to whether the company uses quality management tools and risk awareness. Only about half of the companies meet the corresponding quality standards. The reasons contain that their companies rarely use lean tools and 6 Sigma tools. In addition, not all companies have strong risk management awareness and preventive measures.

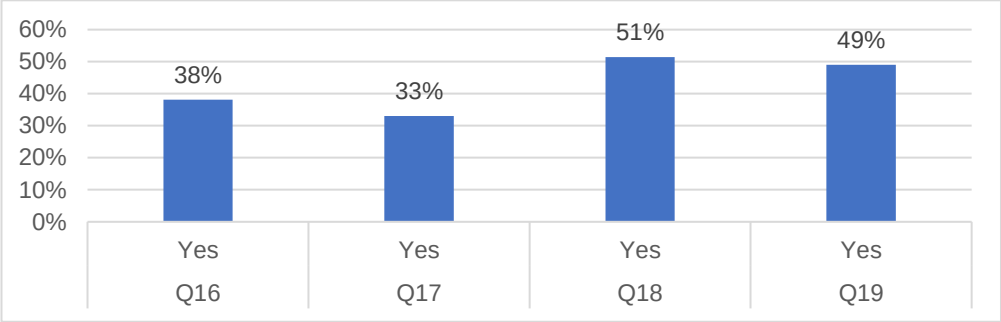

Figure 9: Statistical results of Q16, Q17, Q18 and Q19 answers

The text conclusion of Q16-Q19 on quality tools usage

Table 2: Specific quality tools from respondents

Q16	6 Sigma, 8D, JIT, Kaizen, Kanban, Lean, PDCA cycle, PowerBi
Q17	Fishbone, 6 Sigma, Minitab, DMAIC, 7 highly effective habits.
Q18	Audit, Poka Yoke, BMC, manual monitor meetings, cost front-end control, staff management, early warning and filing, due diligence, analyze details from every aspect before procurement, localized procurement, diverse resources, mainly manual work, preventive assessment of shortages, and delayed news.
Q19	ISO 9001, ISO 15189, RoHS, GS, CE, UL, ASPICE, CPSIA, CA65, REACH, ISO13485.

Some of respondents gave the specific lean tools, the methods of 6 Sigma, the measures of risk management and the corresponding quality standards, see Table 2 above. Except this text contents, there are still many lean and 6 Sigma tools including the 5 ways, the 5s system, value stream mapping, regression analysis, pareto chart, FMEA and so on (SSDSI, n.d.). In addition, the preventive measurements of risk management also include SWOT analysis and detecting loopholes early through deduction and prepare for mistakes early. Combined with the methods in the text, it can also give enterprises some suggestions and inspirations.

3.4 Reliability, validity analysis, hypothesis analysis and correlation analysis

Reliability analysis

There are 6 questions in questionnaire 1 that are scale questions. These questions examine the respondents' attitude towards the efficiency and suggestion use of AI technology in various aspects of the supply chain. So, the validity and reliability of these 6 questions can be analyzed. It can be measured using a Likert scale. The 6 questions are Q6, Q8, Q10, Q12, Q13 and Q15.

Q6, Q8, Q10, Q12 and Q13 have the same answer options: 0-10%, 11%-20%, 21%-30%, 31%-40%, 41%-50%, Over 50% are assigned points of 1, 2, 3, 4, 5 and 6 respectively. And assign scores of 1, 2, 3, 4, and 5 to Q15 options: Completely disagree, somewhat disagree, neutral, somewhat agree, completely agree respectively.

Most used reliability test method is Cronbach's coefficient alpha, which is a statistical model established by the American psychologist and educator Cronbach for determining measurement error. The reliability coefficient is also called the internal consistency coefficient or alpha coefficient (Yin, 2021). When $\alpha \geq 0.9$, the inter construct correlation is excellent; when $0.7 \leq \alpha < 0.9$, the inter construct correlation is good; when $0.6 \leq \alpha < 0.7$, the inter construct correlation is acceptable; when $0.5 \leq \alpha < 0.6$, the inter construct correlation is weak; when $\alpha < 0.5$, the inter construct correlation is unacceptable. The high Cronbach's alpha values indicated great reliability. The reliability results of 6 questions can be analyzed through SPSS software. The comprehensive Cronbach's alpha coefficient value of these 6 questions is 0.85>0.7, so the inter construct correlation is good. At the same time, it also indicated great reliability.

As can be seen from Table 3, if Q6 or Q8 or Q10 or Q12 or Q13 are deleted, the Cronbach's alpha values are smaller than the alpha values 0.85 but are also greater than 0.7. Therefore, the internal consistency of these 5 questions is very good. And if the Cronbach's alpha value after deleting Q15 is 0.878>0.85, it means that if Q15 is deleted, the internal consistency will be better. However, it

is also considered that the scale selected for Q15 is 5-level, which is different from these 5 questions, which are 6-level, and the existence of Q15 will not worsen the internal consistency of the remaining five questions. Therefore, the reliability of these 6 questions is good. This also shows that these questionnaires from the respondents are authentic and reliable. The respondents answered these questions carefully. Then the answers to these 6 questions are real and valid, and the conclusions drawn are reliable.

Table 3: Result of item-total statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q6	16.13	27.905	.629	.432	.826
Q8	16.50	27.041	.731	.593	.804
Q10	16.08	27.821	.688	.534	.813
Q12	15.98	25.692	.772	.656	.794
Q13	16.38	27.930	.704	.559	.810
Q15	16.11	37.198	.238	.073	.878

Validity analysis

Validity analysis tests whether the questions designed by the investigator are scientific and whether the items represent a certain variable appropriately. General validity analysis usually has three steps (Yin, 2021). First, the Kaiser-Meyer-Olkin (KMO) value and Bartlett sphericity test P value are used to determine whether to perform factor analysis. Secondly, the variance explanation rate and total variance explanation rate are used to determine whether factor rotation matrix analysis can be performed. Finally, a rotated factor analysis is performed, mainly looking at the factor loading coefficient values to determine whether the factors are closely related.

Through SPSS software, KMO=0.83>0.5, P<0.01, so it is suitable for factor analysis.

Table 4: Total variance explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.443	57.381	57.381	3.443	57.381	57.381
2	.935	15.580	72.961			
3	.608	10.128	83.088			
4	.457	7.621	90.710			
5	.330	5.493	96.203			
6	.228	3.797	100.000			

Extraction Method: Principal Component Analysis.

However, it can be seen from the factor analysis in Table 4. There is only one factor with an eigenvalue greater than 1, that is 3.44, and the cumulative variance contribution rate of this factor is 57.4%. This suggests that there is strong collinearity among the variables and one factor can explain most of the covariance. Hence, the values of KMO and P are considered acceptable.

Questionnaire 1 was not pilot tested and was directly sent to the target population for investigation. Through the above reliability and validity analysis of these 6 questions scale questions, it can be concluded that the design of these 6 questions is reasonable and acceptable. Moreover, the results of the test can be concluded that the 6 questions in the recycled questionnaire 1 have a high degree of reliability. And the answers to these 6 questions are authentic and reliable.

Hypothesis analysis

Four of the questions in questionnaire 1 are whether AI technology is used in each link of supply chain or not. The four questions are Q5, Q7, Q9 and Q11. Q13 is about product performance improvement and defect rates reduction. The hypothesis method is used to test the relationship between AI technology usage and product performance improvement & defect rates reduction.

First, the data of the answers to these four questions are preprocessed. The answer No is replaced with the value 1. The answer Yes is replaced with the

value 2. Hypotheses and analyzes are performed by logistic regression.

In statistics, significance levels are usually used for hypothesis testing. The significance level usually indicates 0.05. In hypothesis testing, if the calculated *p*-value is less than or equal to the significance level 0.05, then the null hypothesis (H_0) is rejected, otherwise the null hypothesis is accepted (Bevans, 2023).

Null hypothesis H_0: There is a significant close relationship between the use of AI technology in various aspects of the supply chain and improving product performance and reducing defect rates.

This hypothesis tests whether the use of AI technology in these four issues in the purchasing department, manufacturer/supplier, warehouse department and transportation logistics department is related to improving product performance and reducing defect rates. That is to study the linear relationship between questions Q5, Q7, Q9, Q11 and Q13, and use the multiple logistic regression method to obtain the data in Table 5 below.

From Table 5, it is great obvious that all the levels of significant value *p* from Q13 are more than 0.05, when the answers of Q5, Q7, Q8, Q9 are 1 (No). Hence null hypothesis H_0 is accepted. This proves that there is a significant close relationship between the use of AI technology in various aspects of the supply chain and improving product performance and reducing defect rates. Thus, it also can be concluded that the use of AI technology in procurement departments, manufacturer/supplier, warehouse department and transportation logistics department have a positive effect on improving product quality.

Table 5: Multiple logistic regression parameter estimates

Parameter Estimates

Q13[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
2	Intercept	.997	.716	1.940	1	.164			
	[Q5=1]	1.991	1.226	2.639	1	.104	7.323	.663	80.894
	[Q5=2]	0[b]	.	.	0	.	.	.	.
	[Q7=1]	-1.509	.827	3.325	1	.068	.221	.044	1.120
	[Q7=2]	0[b]	.	.	0	.	.	.	.
	[Q9=1]	.907	.814	1.242	1	.265	2.478	.502	12.220
	[Q9=2]	0[b]	.	.	0	.	.	.	.
	[Q11=1]	-1.282	.795	2.598	1	.107	.278	.058	1.319
	[Q11=2]	0[b]	.	.	0	.	.	.	.
3	Intercept	1.105	.685	2.597	1	.107			
	[Q5=1]	2.140	1.117	3.669	1	.055	8.499	.951	75.919
	[Q5=2]	0[b]	.	.	0	.	.	.	.
	[Q7=1]	-.231	.759	.093	1	.761	.794	.179	3.512
	[Q7=2]	0[b]	.	.	0	.	.	.	.
	[Q9=1]	.069	.697	.010	1	.921	1.072	.273	4.205
	[Q9=2]	0[b]	.	.	0	.	.	.	.
	[Q11=1]	-.830	.705	1.386	1	.239	.436	.110	1.736
	[Q11=2]	0[b]	.	.	0	.	.	.	.
4	Intercept	.484	.761	.405	1	.525			
	[Q5=1]	1.519	1.243	1.493	1	.222	4.568	.399	52.261
	[Q5=2]	0[b]	.	.	0	.	.	.	.
	[Q7=1]	-.692	.852	.659	1	.417	.501	.094	2.661
	[Q7=2]	0[b]	.	.	0	.	.	.	.
	[Q9=1]	.307	.815	.142	1	.706	1.359	.275	6.716
	[Q9=2]	0[b]	.	.	0	.	.	.	.
	[Q11=1]	-.606	.813	.555	1	.456	.546	.111	2.684
	[Q11=2]	0[b]	.	.	0	.	.	.	.
5	Intercept	.314	.842	.139	1	.709			
	[Q5=1]	2.172	1.388	2.449	1	.118	8.778	.578	133.330
	[Q5=2]	0[b]	.	.	0	.	.	.	.
	[Q7=1]	.219	1.021	.046	1	.830	1.245	.168	9.206
	[Q7=2]	0[b]	.	.	0	.	.	.	.
	[Q9=1]	-.820	.982	.697	1	.404	.440	.064	3.019
	[Q9=2]	0[b]	.	.	0	.	.	.	.
	[Q11=1]	-2.144	1.059	4.098	1	.043	.117	.015	.934
	[Q11=2]	0[b]	.	.	0	.	.	.	.
6	Intercept	1.017	.753	1.824	1	.177			
	[Q5=1]	2.313	1.628	2.018	1	.155	10.104	.415	245.719
	[Q5=2]	0[b]	.	.	0	.	.	.	.
	[Q7=1]	-1.472	1.119	1.729	1	.189	.229	.026	2.059
	[Q7=2]	0[b]	.	.	0	.	.	.	.
	[Q9=1]	-.341	1.096	.097	1	.756	.711	.083	6.089
	[Q9=2]	0[b]	.	.	0	.	.	.	.
	[Q11=1]	-21.296	.000	.	1	.	5.638E-10	5.638E-10	5.638E-10
	[Q11=2]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 1.
b. This parameter is set to zero because it is redundant.

Moreover, from the above result of hypothesis analysis, Q5, Q7, Q9, Q11 and Q13 that's various aspects of the supply chain using AI technology and improving product quality has a significant relationship. In summary, product quality can be improved through using AI technology in various aspects of the supply chain.

Correlation analysis

The above questions are about the analysis of the use of AI technology in the supply chain and the improvement of efficiency. The next four judgement

questions are about the analysis of whether to use quality management tools and quality standards. These four questions also have text fill-in options. If the answer to them is yes, they can choose to fill in the specific tools and standards. These four questions are Q16, Q17, Q18 and Q19. For these four questions, the answer data needs to be filtered and cleaned first. First, the answer No is replaced with the value 1. The answer Yes is replaced with the value 2. Secondly the filled-in text is sorted and summarized, the Chinese text is translated into English text, overlapping text answers are deleted, and finally the final streamlined text answer is obtained. Thirdly, Pearson correlation analysis was performed on these four questions Q16, Q17, Q18, and Q19.

As can be seen from Table 6, the Pearson correlation coefficients between Q16, Q17, Q18 and Q19 are all between 0.5-0.6. The corresponding significance values are 0<0.05. This means there is the same trend between these four variables. There is a moderate degree of linear correlation. And this relationship is statistically significant. The linear relationship between these four variables is relatively strong, but not very strong. Then further analysis needs to be done through the relationship diagram.

Table 6: Bayes factor inference on pairwise correlations from Q16-Q19

Bayes Factor Inference on Pairwise Correlations[a]

		Q16	Q17	Q18	Q19
Q16	Pearson Correlation	1	.542	.605	.569
	Bayes Factor		.000	.000	.000
	N	105	103	105	104
Q17	Pearson Correlation	.542	1	.545	.544
	Bayes Factor	.000		.000	.000
	N	103	103	103	103
Q18	Pearson Correlation	.605	.545	1	.520
	Bayes Factor	.000	.000		.000
	N	105	103	105	104
Q19	Pearson Correlation	.569	.544	.520	1
	Bayes Factor	.000	.000	.000	
	N	104	103	104	104

a. Bayes factor: Null versus alternative hypothesis.

From the relationship diagram Figure 10, it can be further verified that these four variables Q16, Q17, Q18 and Q19 have the same linear relationship with each other. Therefore, it can be clearly concluded that there is a linear

relationship with the same trend degree between quality tools and standards. This means using lean tools, 6 Sigma tools, risk management and meeting quality standards has certain significance.

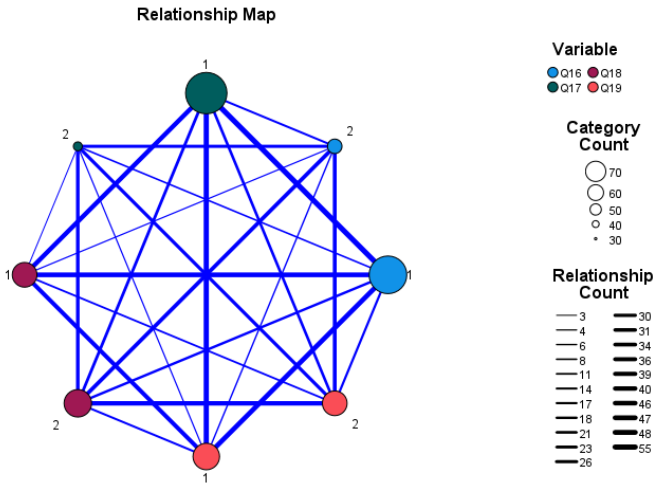

Figure 10: Relationship map from Q16-Q19

3.5 Analysis of open questions

Questions 14 and question 20 in Questionnaire 1 are two open-ended questions. The main purpose in designing these two questions is to allow the respondents to not be restricted by the answers and they can answer the questions from their professional perspective. Thus, more unexpected answers can be obtained.

The analysis of Q14

Word Cloud is used to analyze the advantages and disadvantages of their use of AI technology.

Figure 11: The advantages of AI from the respondents' perspective

Figure 11 shows Word Cloud statistics of their opinions on the advantages of AI. It is concluded that most of the respondents believe that the advantages of AI are efficiency improvement, rapid data analysis, employee costs and processes reduction.

From Figure 12 below, there are some disadvantages of AI from respondents' opinions. They believe that the disadvantages of AI are high initial investment costs, labor market reduction, lack of flexibility in AI, over-reliance on AI, and inability to predict special environmental conditions.

Figure 12: The disadvantages of AI from the respondents' perspective

The analysis of Q20

About the last open question, many unexpected and surprising answers from

these respondents are obtained. The main contents are summarized in Table 7.

Table 7: Quality improvement suggestions from respondents

Q20: What suggestions do you have for improving product quality (e.g. in terms of product performance, service life, reliability, safety, economy, applicability, appearance quality, service quality, work quality and scrap rate)?
1. Optimize production processes and resource utilization: a) Use automated production lines to replace semi-automatic or manual operations. b) Continuously try and select different production materials to seek more opportunities. c) Introducing new technologies and reliable machines to monitor products in more detail. 2. Improve product quality and employee awareness: a) Develop product control procedures to improve employees' understanding of products. b) Strengthen design quality and continuously improve technological innovation. c) Emphasis on product quality through training. 3. Emphasize customer benefits and services: a) Educate new customers on how to monetize tools, streamline processes and reduce costs. b) Establish systems to manage product performance, reliability and storage, and provide post-transaction services. c) Set corresponding standards for product quality according to the target market and customers, ensuring that national standards are the bottom line. 4. Implement international quality system standards and continuous improvement: a) Follow international quality system standards. b) Continuous improvement, introducing advanced concepts such as supplier management, inventory management, information sharing, performance evaluation, etc. c) Optimize processes and focus on safety, reliability and cost-effectiveness. 5. Strengthen quality control and supervision: a) Plan and prevent, conduct online visual inspections. b) Control raw materials and quality and establish more detailed quality control processes. c) Conduct external inspections and internal inspections according to national standards and establish sample reminders to prevent defects from occurring.

It can be seen from experts in these supply chains and other positions have given a variety of opinions on improving quality. These opinions are almost all-encompassing. They contain raw material control, product design optimization, production process refinement, and the overall process of quality inspection

standardization. They also include improving quality management levels and introduction of advanced technologies and innovative ideas. Certainly, they promote preventive measures and product reliability verification. They emphasize employee training and core competitiveness in better serving customers. These have comprehensively summarized how to better improve quality and efficiency in enterprises. Moreover, the following methods are still of great reference significance for China's small and medium-sized enterprises.

3.6 The conclusion of questionnaire 1

From the above analysis to questionnaire 1, It can be concluded that the improvement of supply chain management efficiency is related to the use of AI technology. And the improvement of product quality and reduction of defect rates are directly related to the use of AI technology and quality tools. However, the average proportion of Chinese companies using advanced AI technology and quality tools is less than half. More than half of supply chain experts remain neutral on strongly recommending the use of AI technology. Part of the reason is that they only work in one link of the supply chain and are not very familiar with the specific applications of AI in other supply chain links. Another part of the reason is that the cost of using AI technology is beyond what companies can afford. In conclusion, AI technology and quality indeed improve the quality of products.

4. Questionnaire 2

Questionnaire 2 also contains 20 questions, mainly targeting international customers. It can be shown which CBEC platforms they shop on. What categories of products will they buy? What kind of pages can entice them to buy? What is the definition of a good product? How will they deal with poor quality products? Under what circumstances are positive and negative reviews made? What are the advantages and disadvantages of the cross-border e-commerce platform? How satisfied are they overall with the products on the CBEC platform? The specific contents are seen in appendix 2. The 20 questions are showed as follows:

Q1': Your age.

Q2': Your occupation.

Q3': What is your average monthly income without taxes (=gross income)?

Q4': Where do you come from?

Q5': Which cross-border e-commerce platforms do you often shop on (You can choose up to 3)?

Q6': How often do you purchase on cross-border e-commerce platforms?

Q7': Which categories of products do you buy the most on these platforms (You can choose up to 3)?

Q8': What kind of web interface on the cross-border e-commerce platform website will most attract you to click and browse?

Q9': For the same product on the same cross-border e-commerce platform, what makes you decide to buy products from store A instead of products from store B or C?

Q10': Which of the following do you think best defines a good product quality?

Q11': Do you often have good shopping experience (for example, are you satisfied with the appearance, availability, functionality, service, and so on) on cross-border e-commerce platform?

Q12': Do you often purchase the products from the same store, where you had good experience?

Q13': Do you may be pleasantly surprised to receive an extra thank you note or small gift with your product?

Q14': Do you often give feedback on the cross-border e-commerce platform where you purchase?

Q15': Do you often give a good review?

Q16': Do you often give a negative review?

Q17': What to do if you receive poor quality or unsatisfactory products?

Q18': What do you think are the advantages of cross-border e-commerce platforms?

Q19': What do you think are the disadvantages of cross-border e-commerce platforms?

Q20': Overall, are you satisfied with the product quality on cross-border e-commerce platforms?

4.1 The process of collecting questionnaire 2

The target group of the questionnaire 2 is international customers, whose ages are above 18 years old. The cover letter was placed at the head of questionnaire 2, see appendix 4. Questionnaire 2 was sent to investigators, who live abroad and come from other countries with non-probability. In addition, I also asked my foreigner friends to send questionnaire 2 to their friends. Finally, 103 surveys were received from 30.1-19.3.2024. The target number of respondents for Questionnaire 2 is 1,000 people. However, only 103 surveys were received. Sample size is calculated below.

4.2 Sample Size

A total of 362 respondents opened the link, 114 respondents answered the question, and a total of 103 surveys were finally received feedback on questionnaire 2 with an answer rate of 90%. The specific feedback situation is shown in Table 8. According to the equation (1), n=103 respondents the error

margin is about 10%.

Table 8: the specific feedback situation on questionnaire 2

	Total	
	(N)	%
Submitted responses: Public weblink	103	90
Survey opened by respondents	362	317
Started responding	114	100

4.3 Qualitative analysis of the answers of 20 questions in questionnaire 2

For the convenience of data analysis, keywords are used to replace the 20 questions in Questionnaire 2. The alternative keywords are displayed as follows: Q1': Age. Q2': Occupation. Q3': Salary. Q4': Country. Q5': Platforms. Q6': Frequency. Q7': Categories. Q8': Attract highlights. Q9': Determining factors. Q10': Good product definition. Q11': Good experience. Q12': Same store. Q13': Surprised to get extra. Q14': Feedback. Q15': Good review. Q16': Negative review. Q17': Poor quality. Q18': Advantage. Q19': Disadvantage. D20': Satisfying.

The distribution of answers to the same or similar question types among these 20 questions is displayed on the same histogram. The salary is filled in in the form of text, and the data is sorted and arranged from high to low according to different occupations. In addition, since the Q5' platform and Q7' category allow respondents to select the three most frequently used and purchased ones, their answer distributions are displayed in histograms respectively.

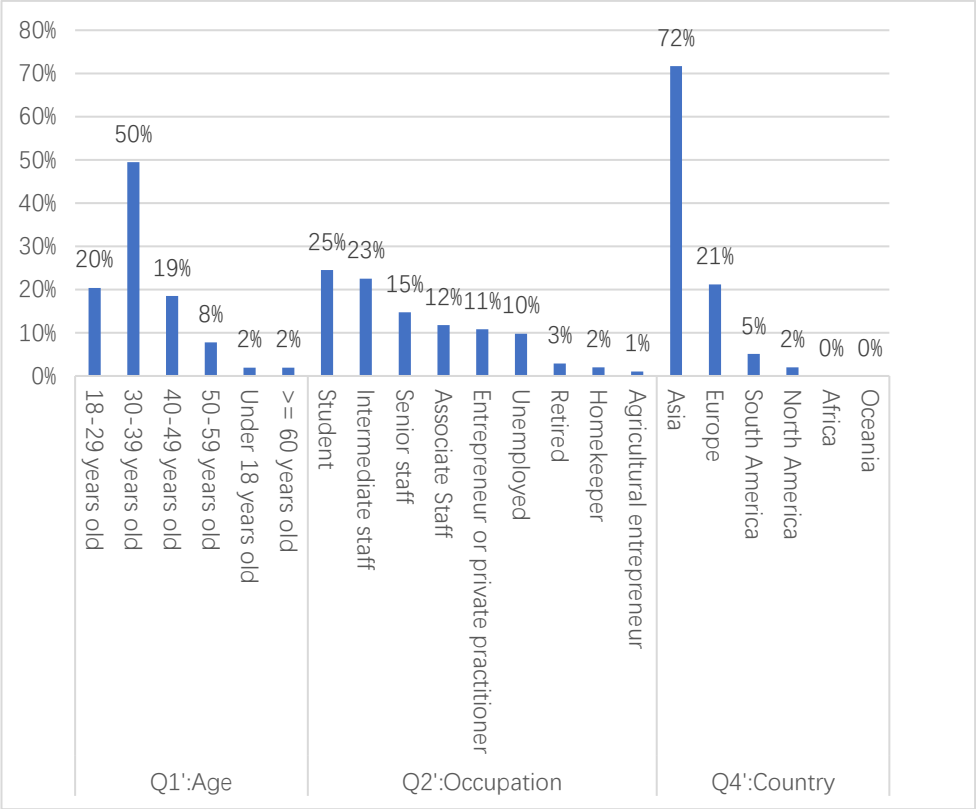

Figure 13: The distribution of Q1', Q2' and Q4'

From Figure 13, 50% respondents are aged 30-39. 20% and 19% of respondents are aged 18-29 and 40-49 respectively. Nearly 90% of respondents are under 50 years old. The occupation of 25% and 23% respondents are students and intermediate staff respectively. More than 10% but less than 20% of respondents' occupations are senior staff, associate staff, entrepreneur or private practitioner and unemployed. It can be concluded that these respondents are engaged in different occupations. In addition, more than 70% of them come from Asia and more than 20% of them come from Europe. Clearly, the range of respondents is somewhat limited to Asia and Europe.

Table 9: The distribution of Q3'

Report

Salary

Mean	N	Minimum	Maximum	Median	Std. Deviation
2514.61	72	0	12000	2350.00	1756.654

As can be seen from Table 9, their average salary is 2,515 euros, which means they have quite enough financial resources to purchase products from CBEC platforms.

Q5' and Q7' have one or two or three answers, which made the overall analysis more complicated. Therefore, Q5' and Q7' had independent histograms, see Figure 14 and Figure 15.

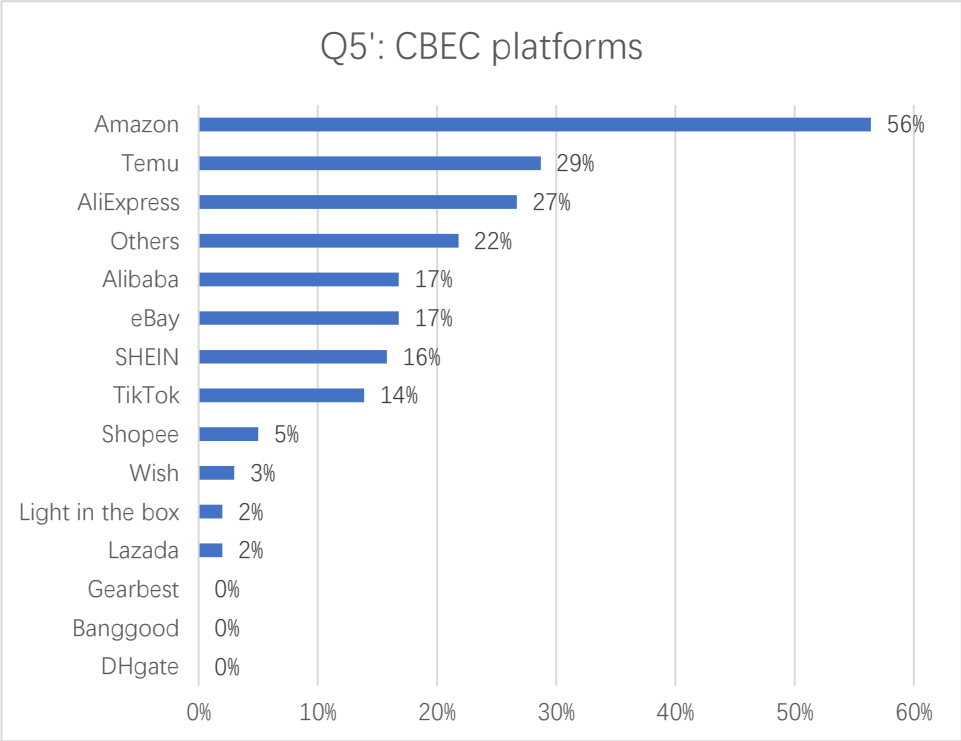

Figure 14: The distribution of Q5'

From Figure 14, more than half of international customers purchased products from Amazon, making it the platform with the most purchases. Then, Temu (29%) and AliExpress (27%) ranked second and third. Alibaba, eBay, SHEIN and TikTok account for nearly 15%. In addition, few international customers chose Wish, Lazada, Shopee, Dhgate, Banggood and Gearbest for purchases. Other platforms included Taobao, JD.com, Jiji, Boozt, Zalando, WhatsApp, iHerb, Buscalibre, and Best Secret, which are local e-commerce platforms in China, Finland, and other countries respectively. It is obvious that Chinese small

and medium-sized enterprises can choose Amazon, Temu, AliExpress, Alibaba, eBay, SHEIN and TikTok platforms. This way they can get more views and purchases from international customers.

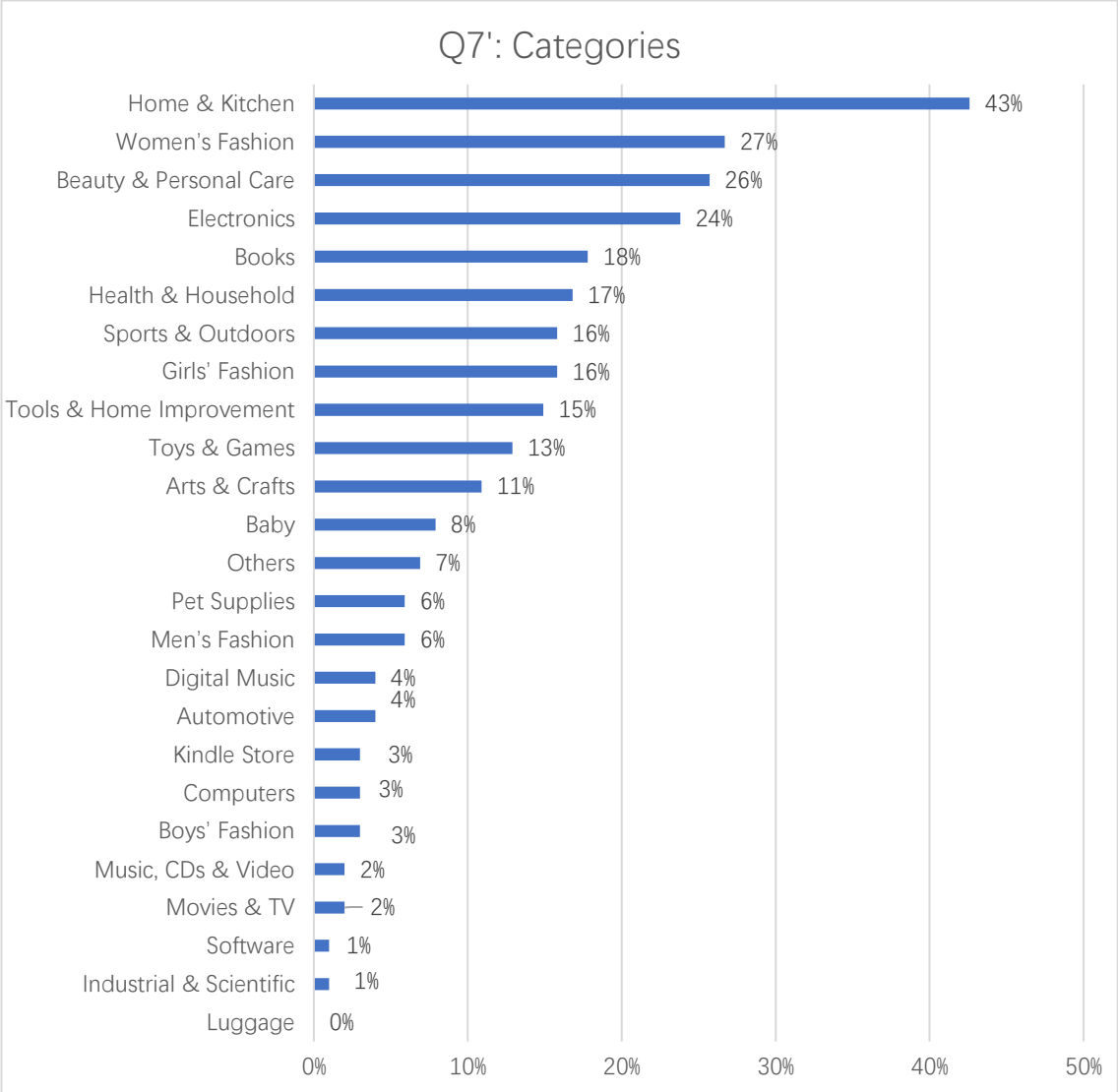

Figure 15: The distribution of Q7'

It is evident from Figure 15 that 43% of international customers purchase home and kitchen categories from the CBEC platform. 27%, 26% and 24% purchased women's fashion, beauty and personal care and electronic products respectively. Among them, nearly 15% of respondents chose to buy products such as girls' fashion, healthy home, sports and outdoor, tools and home

decoration, toys and games from CBEC platforms. It can be concluded that the above categories are most popular among international customers.

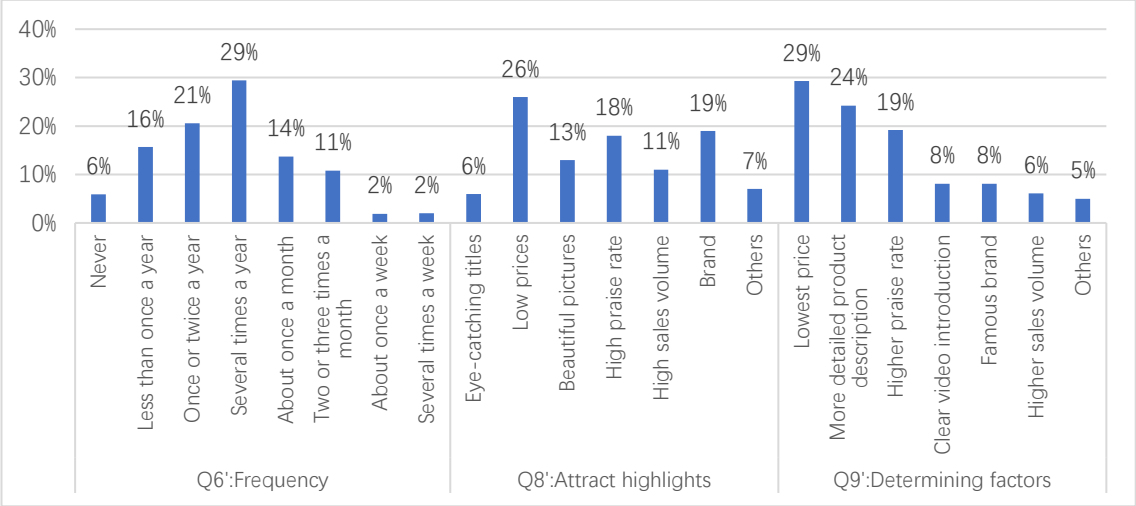

Figure 16: The answers of Q6', Q8', and Q9'

From Figure 16, 29% of the respondents only purchased products from CBEC platforms several times a year. 21% of them chose it only once or twice a year. Among them, 16%, 14% and 11% chose less than once a year, about once a month and two to three times a month. They do not often purchase products from CBEC platforms. Low prices, brand and high praise rate were the highlights of CBEC web pages that attracted respondents the most. The proportions were 26%, 19% and 18% respectively. Then 13% and 11% of them thought that beautiful pictures and high sales volume were also important factors that attracted them. Then the lowest price, more detailed product description and higher praise rate were the most important factors that motivated them to buy the product. The proportions were 29%, 24% and 19% respectively.

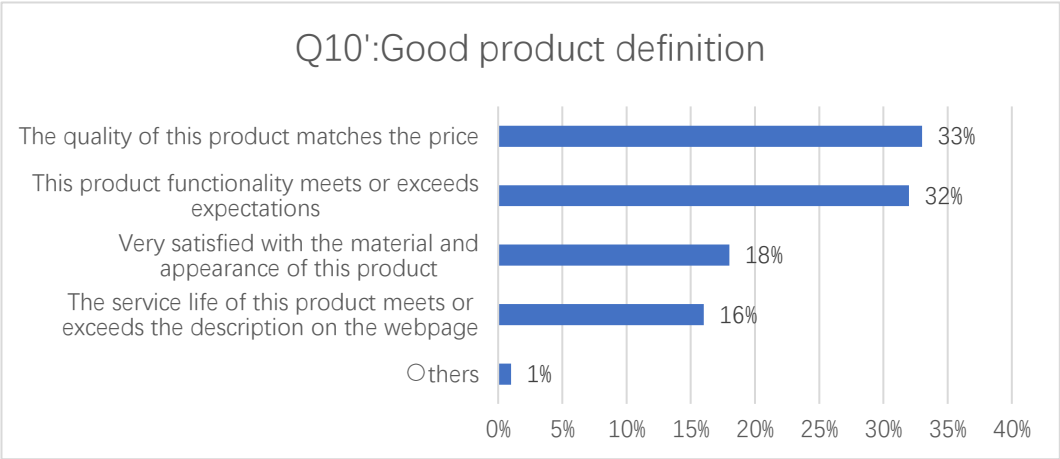

Figure 17: The answers of Q10’

In addition, From Figure 17, 33% and 32% respectively believed that good products could match the price and the functions could meet or exceed expectations.

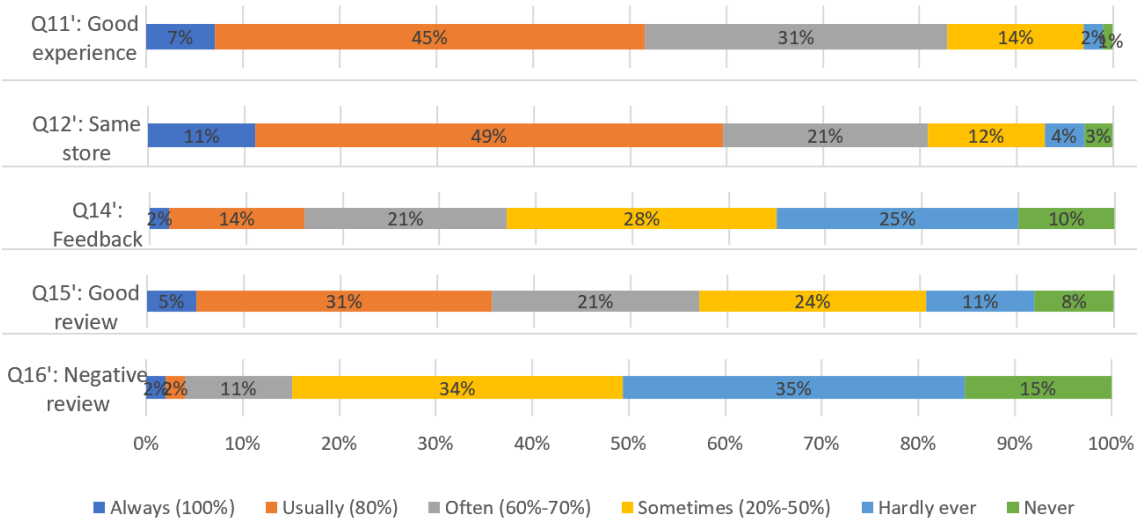

Figure 18: The answers of Q11’, Q12’, Q14’, Q15’ and Q16’

The five questions Q11’, Q12’, Q14’, Q15’ and Q16’ had the same options. Therefore, the answers to these 5 questions were presented in the form of a bar graph, as shown in Figure 18. 76% of respondents had a quite good experience shopping on the CBEC platforms. 70% chose to buy products from the same

store. 28% only sometimes left feedback. And 25% hardly ever left feedback. 35% quite often gave feedback. 31% usually gave good reviews. 24% sometimes left good reviews and 21% often gave good reviews. In addition, 35% and 34% hardly ever or sometimes gave negative reviews. And 15% never gave a negative review. It can be concluded that most of them have good experience of CBEC platforms and they purchase products from the same store. Additionally, most of them quite often leave good reviews.

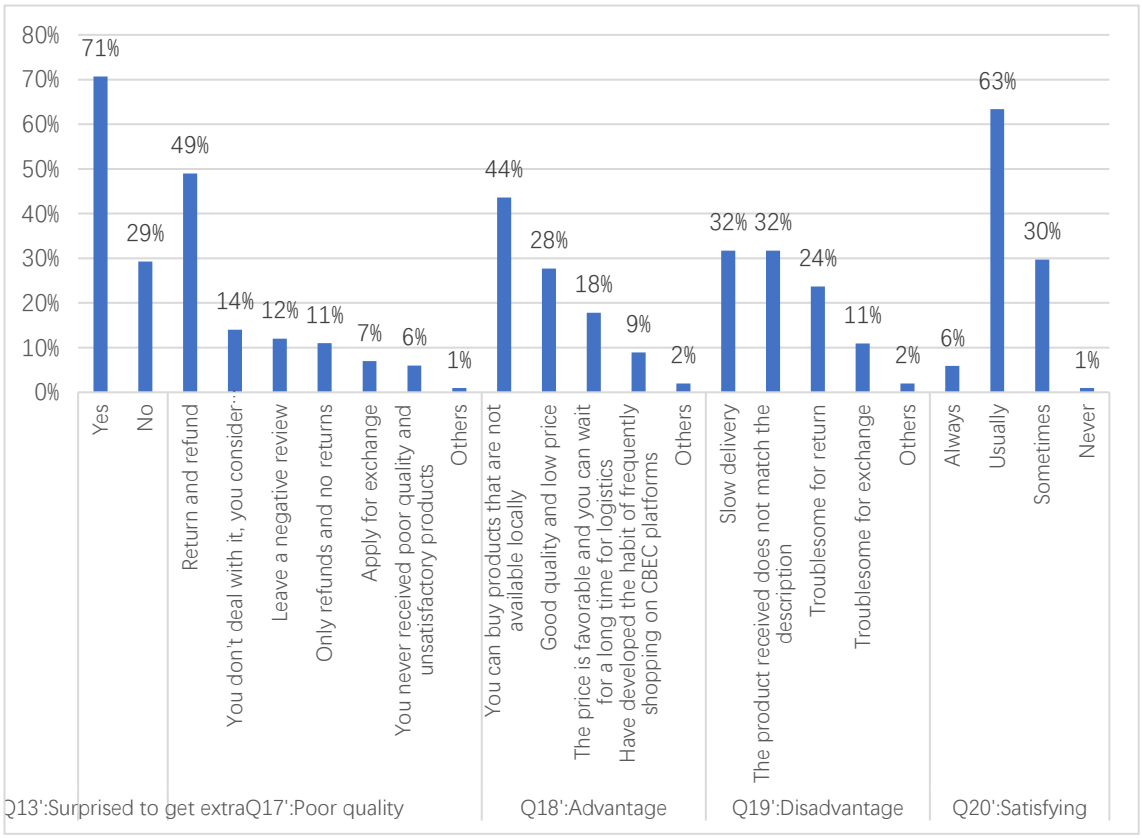

Figure 19: The answers of Q13', Q17', Q18', Q19' and Q20'

As can be seen from Figure 19, 71% of the respondents were surprised to receive a thank-you letter or small gift. When they received a defective product, 49% returned it for a refund. 14% did not solve the problem and considered themselves unlucky. 12% of them left negative reviews. Among them, 11% only provided refunds but did not return goods. Regarding the advantages of CBECD platforms, 44% of them believed that they could buy products that were

not available locally. 28% of them valued good quality and low price. 18% of them were satisfied with the price and could wait a long time for logistics. Regarding the shortcomings of CBEC platforms, 32% of respondents said that delivery was slow, and the products received did not match the description. 24% found it difficult to return items. Overall, 63% of them were generally satisfied with the products of CBEC platforms. 30% of them were sometimes satisfied with the product and 6% were always satisfied. It shows that most international customers are satisfied with the products of CBEC platforms.

In summary, although the international customers don't often purchase the products from CBEC platforms, they have good shopping experience. Generally, they are satisfied with the products. The answers of questionnaire 2 can be used by companies to improve the product quality and service of CBEC platforms.

4.4 Big data analytics of the questionnaire 2

BDA was used to analyze the correlation of the 20 questions. Python was used as the main analysis tool. 103 questionnaires were analyzed by heatmap after data cleaning, sorting, missing value processing, numerical characterization and data scaling. Finally, the random forest regression model was used as the international customer satisfaction trend analysis model to perform model optimization, mean square error and accuracy analysis. CBEC companies can use random forest regression models to analyze satisfaction trends from reviews left by international customers. In this way, they can find out the points of dissatisfaction with the product to adjust and improve.

Heatmap correlation analysis

Questionnaire 2 contains 20 questions. Except for salary, which is a numerical value, the other 19 questions are text multiple choice questions. For Q5' and

Q7', which had 1 or 2 or 3 answers, the option with the largest proportion was used for analysis. For Q3', which is salary, the missing value was replaced with the average salary for each occupation. The missing value in the answers to the other 17 questions were replaced by the most selected options. After data cleaning, the first ten cleaned and sorted data are shown in appendix 5. Then this data was uploaded into Python. The data was numerically characterized and scaled. Then I used the correlation heatmap code and got the following Figure 20.

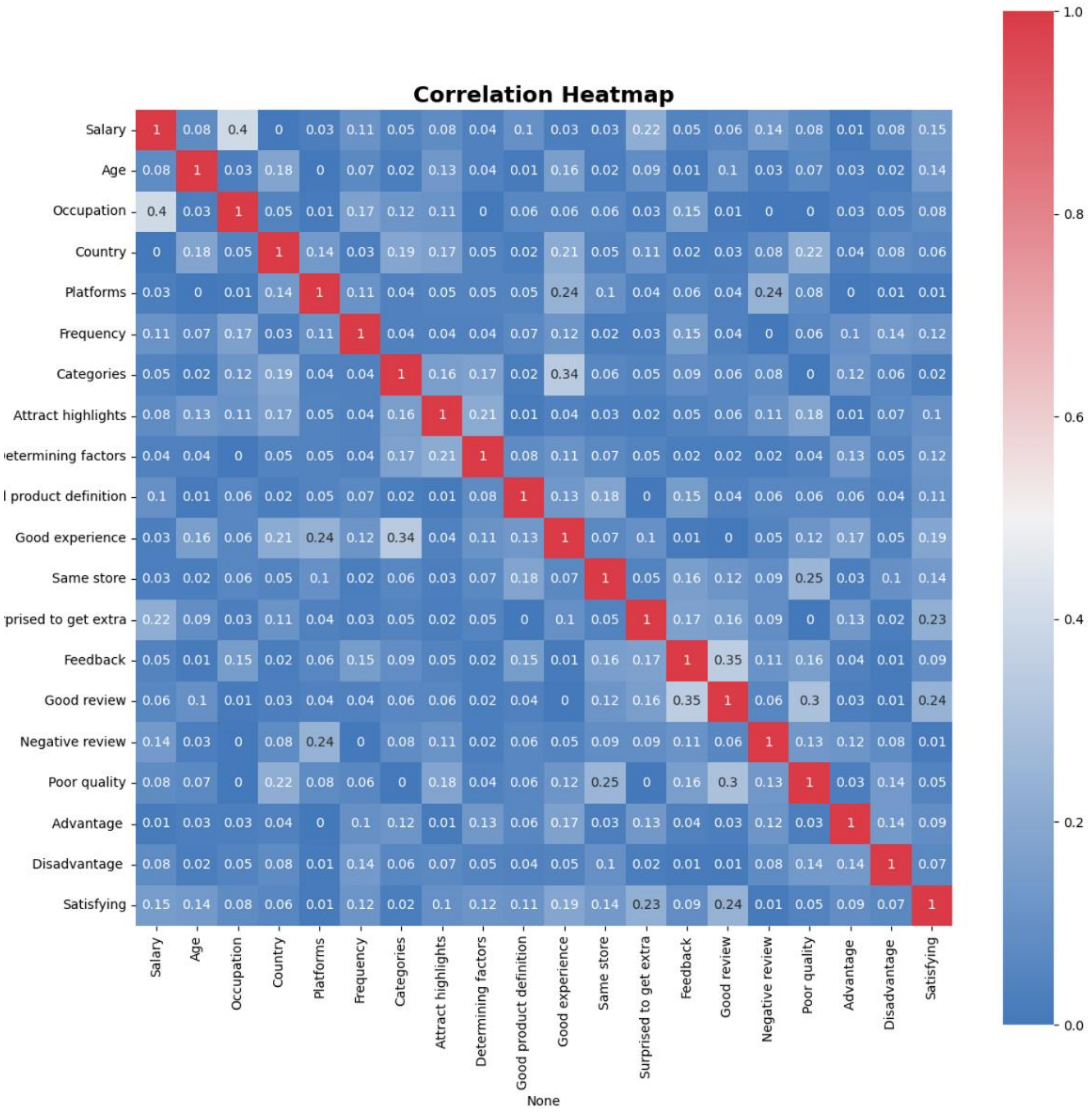

Figure 20: The correlation heatmap

As can be seen from Figure 20, the 20 questions in Questionnaire 2 do not have much correlation after heat map analysis. This means that there is no obvious correlation or pattern between the responses to the various questions in questionnaire 2. It can be concluded that customer satisfaction is affected by multiple factors, which include these 20 questions. And the relationship between these factors is not direct or linear.

Random forest regression model

In questionnaire 2, 19 questions were used as dependent variables, and the last question Q20' on overall satisfaction with the product was used as an independent 'y' variable. The main purpose is to observe the relationship between the dependent variable and the independent variable. Then the scaled data was split into training set and test set data. Then the random forest model was built to calculate the accuracy and mean square error, as shown in Table 10 and 11 respectively.

Table 10: The random forest regression model

```
from sklearn.ensemble import RandomForestRegressor
Rforest = RandomForestRegressor(n_estimators=80, max_depth=10, min_samples_split=2, random_state=123)
Rforest.get_params()
```

```
{'bootstrap': True,
 'ccp_alpha': 0.0,
 'criterion': 'squared_error',
 'max_depth': 10,
 'max_features': 1.0,
 'max_leaf_nodes': None,
 'max_samples': None,
 'min_impurity_decrease': 0.0,
 'min_samples_leaf': 1,
 'min_samples_split': 2,
 'min_weight_fraction_leaf': 0.0,
 'n_estimators': 80,
 'n_jobs': None,
 'oob_score': False,
 'random_state': 123,
 'verbose': 0,
 'warm_start': False}
```

```
Rforest.fit(X_train, y_train.values.ravel())
```

```
RandomForestRegressor
RandomForestRegressor(max_depth=10, n_estimators=80, random_state=123)
```

Table 11: The mean square error and accuracy

```
from sklearn.metrics import mean_squared_error, r2_score
mse = mean_squared_error(y_train, Rforest_y_pred)
print("Mean Squared Error:", mse)
r2 = r2_score(y_train, Rforest_y_pred)
print("R-squared Score:", r2)
```

```
Mean Squared Error: 0.008547075473196117
R-squared Score: 0.864028701541552
```

From Table 11, the mean squared error is 0.009 and the accuracy is 86.4%. It shows that the random forest regression model is an excellent model from the above results. This model can be used to predict the overall satisfaction of international customers with products on CBEC platforms. This can serve as a guideline for the company. And it helps to optimize and improve the details, services and product quality.

4.5 Summary of questionnaire 2

In conclusion, by understanding the purchasing preferences of international customers on the CBEC platform, CBEC can deeply understand customer needs and discover its own shortcomings. Then make improvements based on these needed details to gain more customer trust and praise, thereby making more sales for the company.

At the same time, analyzing customer satisfaction trends through BDA can provide customer demand direction and positioning for small CBEC companies with insufficient funds. The model established through self-built BDA can help the company discover problems and reduce the cost of using third-party AI software, thereby obtaining greater benefits for the company.

5. Semi-structured interview summary

During a semi-structured interview with a purchasing manager, who has worked in the CBEC industry for 9 years, I learned about her company's product returns and quality control. First, her company's CBEC products cover a wide range of categories. The return ratio for each category of products varies, usually exceeding 1%. Reasons for product returns generally include logistics problems, product incompatibility, product defects, and unreasonable returns. Second, most of the products returned by customers are discarded, and almost none are returned to China. Because the return shipping costs and time are too long. Third, her company's quality control of products requires factories to conduct full inspections. Her company will conduct proportional random inspections in accordance with the corresponding national quality standards. For quality issues reported by customers, her company will also provide feedback to the factory. Then the factory cooperates to resolve quality defects. Fourth, her company will also improve operational service issues within the company. For example, they solve return problems caused by errors in descriptions, exaggerated functions, etc.

In addition, I also learned about her company's suppliers. Her CBEC company chooses a wide range of suppliers. Most of these suppliers are relatively small. Therefore, these suppliers generally do not have a very complete and scientific quality system for production, such as 6 Sigma. These will make it difficult to control quality at the source of production. She also pointed out that for problems caused by transportation, her company will first conduct packaging and transportation tests on the samples. This reduces the occurrence of product transportation problems. If the product still causes damage during transportation, it is a structural problem with the product itself. This requires the purchasing team to communicate with the factory and improve structure issues.

Table 12: The sales table of ten products in March 2024 from one Chinese CBEC company

Number	Name	picture	Total sales (PCS)	Total sales (€)	Total gross profit (€)	Gross profit margin (%)
1	Electric Baby Bouncer		362	43942	17232	39
2	Hlieeosfcn Caravan Roof Fan		128	22469	7713	34
3	Aomdom Learning Tower		134	12317	5264	43
4	Lischwert Indoor Soft Foam Climber Play Sets		44	7083	2210	31
5	Climbing Triangle for Children		76	5328	2411	45
6	GJCrafts Busy Board Montessori for Toddlers		114	1593	83	5
7	Hlieeosfcn Bed Rails		257	14230	6095	43
8	GJCrafts Extendable Kitchen Faucet		128	3944	455	12
9	Do-Electr Laundry Baskets with Lid		115	2522	571	23
10	Hlieeosfcn 300A Welding Machine		144	10763	3936	37
		Total	**1502**	**124191**	**45909**	**37**

The AI tool used by CBEC is generally the SellerSprite. This AI software can

assist the operations team in product optimization, keyword screening, competitive product analysis, etc. It can also help the purchasing team with hot-selling product analysis. They find products that sell well through BDA. They will also carry out functional innovations based on these best-selling products. In this way, the new products they develop will have a more competitive advantage in the market. She also provided me with 10 products' data found through the SellerSprite AI software. This data includes sales quantity, total sales, gross sales profit and gross profit margin in March 2024, as shown in Table 12. It can be seen from these data that these 10 products sold on Amazon are of different types. These categories include children's products, kitchen products and tools, etc. Their total sales volume in March was 1,502units. Total sales were 124,191 euros. The total gross sales profit was 45,909 euros. The average sales gross profit margin was 37%. Due to the limited data she provided, it cannot be said that all products found through AI intelligent software will have good sales. It can only be said that most of the products found through AI software are profitable and can be more likely to bring revenue to the company.

6. Discussion

The research of this thesis focuses on the relationship between five core elements (AI, SCM, CBEC, customer, quality management) through two web-based questionnaires and semi-structured interviews. It aims to improve product quality by completely exploring the cyclical closed-loop relationship of these five cores. Previous research did not fully include these five core elements for comprehensive analysis. However, this thesis comprehensively studies the contribution of the application of AI technology and QMT in the supply chain to quality improvement. At the same time, the thesis also analyzes their satisfaction with product quality from the perspective of international customers, identifies problems, and feeds them back to the supply chain to form a closed loop of quality improvement. Moreover, this thesis demonstrates this argument through an actual data case of a CBEC company. This provides a more comprehensive and enriched approach to improving the quality of cross-border e-commerce products.

Regarding the three research questions in the introduction, the analysis results of questionnaire 1 clearly answer the first question. That is, using AI technology and quality tools in the supply chain can better improve product quality through AI technology and QMT. A previous study showed that AI can affect supply chain performance (Belhadi et al. 2021). This study further studies how AI can improve efficiency in the supply chain. At the same time, it extends the positive impact of quality tools on quality performance and standards. It also provides an in-depth analysis of the benefits and drawbacks of using AI as well as suggestions from Chinese supply chain experts. Such professional analysis can bring thinking and help to Chinese CBEC companies in the supply chain to better use AI and apply quality tools based on their own economic strength.

From the analysis results of questionnaire 2, it can be clearly concluded that using BDA to analyze international customer satisfaction trends can improve and optimize product quality and services. This is similar to the previous research that uses data fusion algorithms (Zhang et al. 2021) to analyze customers' supply and demand relationships to customize products for customers. Questionnaire 2 starts from the purchasing psychology of international customers in more detail to study customers' purchasing needs, frequency, determinants, experience favorability, evaluation and overall satisfaction on CBEC platforms. At the same time, questionnaire 2 also analyzes the definition of good products by international customers and the analysis of the advantages and disadvantages of CBEC platforms. And a big data random forest regression model is also used to predict international customer satisfaction. Such comprehensive analysis can help Chinese CBEC companies improve product quality and services at the customer level.

The third question can be answered from the semi-structured interviews. That is, products developed using big data and AI technology software generally sell well and can be more likely to bring good profits to CBEC companies. Based on my previous experience in CEBC product development, I already know that there are popular data analysis software for different CBEC platforms on the market. For example, big data and AI software used on the Amazon platform include, in addition to the sellerSprite mentioned above, SurTime, Amazon Captain, Keepa, Amztracker, etc. (LinkFlow, 2023). This very mature big data analysis software can develop hot-selling and competitive products for cross-border companies. And from interviewing the purchasing manager, I can also learn how generally cross-border companies deal with product return defects and how to better improve product quality.

Overall, through two questionnaires and semi-structured interviews, I can comprehensively analyze the relationship between the five core elements

surrounding this thesis: AI, SCM, customers, quality tools and CBEC platforms. This relationship is a closed-loop relationship of circular flow. The analysis results of this thesis can provide valuable reference for Chinese CBEC companies to improve product quality. Of course, this thesis also has some shortcomings, as discussed below.

Limitation

There are three main shortcomings in this thesis: Firstly, the two question designs are relatively subjective, and some designed answers may not include the answers that respondents want to choose. Although there are other options and fillable text at the end of the answer, most of the respondents who chose other options did not fill in the content. In this way, the contents of other options cannot be fully counted during the analysis process, which will result in the lack of some real data. Secondly, although the number of copies of the two sample questionnaires is sufficient, the filling rate of Questionnaire 1 was 76%, and the filling rate of Questionnaire 2 was 90%. The filling rate of both samples did not reach 100%.In addition, 72% of the respondents are from Asia, 21% from Europe, 5% from South America and 2% from North America, while 0% are from Africa and Oceania in Questionnaire 2. This shows that the statistics in Questionnaire 2 did not include customers from all over the world, so the analysis of their views is not very comprehensive. Thirdly, 103 copies of Questionnaire 2 were collected as big data model samples. This number will be relatively small for model prediction analysis and will also cause the calculated model accuracy of 86.4% to be slightly lower. If the model needs to be improved, more sample data is requested.

Future

For the work that needs to be done in the future, I can interview multiple CBEC

companies to gain an in-depth understanding of their entire supply chain system. More direct and objective data can be collected, and then analyzed to summarize their internal deficiencies in quality management and propose improvement measures based on their actual situation. As well as understanding their operations and customer service centers and extracting their analysis of the real needs of international customers, the data obtained will be more three-dimensional and richer. At the same time, I can interview the manufacturing industry to collect information on how they control product quality. Then I can provide targeted suggestions and methods for some quality management systems and quality management tools that small-scale enterprises lack. In addition, for questionnaire surveys of customers around the world, I can cooperate with a CBEC company that has business all over the world. The questionnaires will be distributed to customers who have purchased through their customer service, and international customers can be encouraged to actively participate in the questionnaires by issuing coupons or small gifts as rewards. In this way, more questionnaires can be collected for predictive analysis of more accurate models, thereby better improving service and product quality.

Conclusion

Currently, China's cross-border e-commerce is still in a stage of rapid development. However, product return rates are also relatively high. In addition, for returned products with quality problems, generally CBEC companies will choose to discard them directly. This will not only cause economic losses, but also increase the burden on the environment. Therefore, improving product quality is crucial for CBEC companies. This thesis addresses the three research questions through questionnaire analysis of supply chains and international customers, as well as semi-structured interviews. This can provide CBEC with

more valuable methods on how to improve quality.

Moreover, this thesis establishes a process model of methods to improve product quality around the five core elements of SCM, quality tools, AI, CBEC and customer service requirements. This model can provide CBEC with methods and references on how to improve product quality and reduce return rates. CBEC companies can use AI technology and quality management tools and combine manufacturers and suppliers to control product quality at the source, so that the quality qualification rate of each product reaches the 6 Sigma level. Then through big data to predict customer needs and feedback on product quality and services, CBEC companies can provide customized services and feedback product defects to the supply chain center. The supply chain can make continuous improvements based on feedback on quality issues. This forms a flowing closed-loop process that continuously improves product quality.

Under such process control, the quality can reach zero defects, and the return rate of customers due to product quality problems will be reduced. On the other hand, it is also conducive to the sustainable development of CBEC companies. The company can make more sales and more revenue. As the economy grows, they can make better use of artificial intelligence systems and friendly and environmentally friendly materials. This also protects the environment. In addition, they can increase employee benefits and assume more social responsibility.

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Appendix 1. Questionnaire 1

Questionnaire on AI and quality management technology empowering supply chain management
Q1. Your age：20-29, 30-35, 36-39, 40-45, 46-49, >= 50years old.
Q2. Your industry: Internet/IT/Electronics/Communications, Finance, Pharmaceutical/Medical, Real Estate/Construction, Transportation/Logistics/Trading/Retail, Mechanical/Manufacture, Energy/Chemical Industry/Environmental Protection, Professional service, Life service industry, Consumer goods, Others.
Q3. Your job: Purchaser, Supply Chain Specialist, Senior Purchaser, Supply Chain Specialist, Purchasing Manager, Supply Chain Manager, Purchasing Director, Supply Chain Director, Supplier development, Others.
Q4. Do you have CIPS (Chartered Institute of Purchasing and Supply) certification：No, Yes, Level 4, Yes, Level 5, Yes, Level 6.
Q5. Does your company's procurement system use a digital intelligent platform for full-chain procurement collaborative management (such as SAP, Zhichubao, NLP，ERP and other intelligent systems)? Yes, No.
Q6. You think the intelligent procurement platform has improved procurement efficiency, reduced procurement costs and optimized supplier management: 0-10%, 11%-20%, 21%-30%, 31%-40%, 41%-50%, Over 50%.
Q7. Does the manufacturer or supplier you contacted use artificial intelligence AI technology? Yes, No.
Q8. You think that AI technology improves product quality and production efficiency in terms of quality control, preventive maintenance and intelligent production line optimization: 0-10%, 11%-20%, 21%-30%, 31%-40%, 41%-50%, Over 50%.
Q9. Is your industry's warehouse inventory managed using artificial intelligence systems? Yes, No.
Q10. You think artificial intelligence technology improves warehousing automation, demand forecasting and supply planning: 0-10%, 11%-20%, 21%-30%, 31%-40%, 41%-50%, Over 50%.
Q11. Does the logistics and transportation in your industry use artificial intelligence AI technology or the Internet of Things? Yes, No.
Q12. You think artificial intelligence and IoT combine to improve supply chain management efficiency: 0-10%, 11%-20%, 21%-30%, 31%-40%, 41%-50%, Over 50%.
Q13. You think supply chain management driven by AI technology improves product performance and decline scrap rate: 0-10%, 11%-20%, 21%-30%, 31%-40%, 41%-50%, Over 50%.
Q14. What benefits or disadvantages do you think AI technology brings to supply chain management? Why?
Q15. You strongly recommend that the entire supply chain ecosystem management system uses AI technology: Completely disagree, Somewhat disagree, Neutral, Somewhat agree, Completely agree.

Appendix 1. Questionnaire 1 (continue)

Questionnaire on AI and quality management technology empowering supply chain management
Q16. Does your industry’s supply chain management system use lean tools for continuous quality improvement? If yes, what kind of lean tools? Yes, No.
Q17. Does your industry’s supply chain management system use Six Sigma tools for continuous quality improvement？ If yes, what is the specific method? Yes, No.
Q18. Does supply chain management in your industry have risk management awareness and corresponding preventive measures? If yes, what kind of preventive measures? Yes, No.
Q19. Do your company's products meet the following product quality standards through the use of quality management tools? For example, CPC certification, EN71, FCC certification, ASTM F963, CPSIA (HR4040), CE certification, UL certification, GS certification, ROHS testing and other standards? If yes, what standards are there? Yes, No.
Q20. What suggestions do you have for improving product quality (e.g. in terms of product performance, service life, reliability, safety, economy, applicability, appearance quality, service quality, work quality and scrap rate)?

Appendix 2. Questionnaire 2

Questionnaire for analyzing the purchasing behavior of international customers on CBEC platforms
Q1. Your age: Under 18, 18-29, 30-39, 40-49, 50-59, >= 60 years old.
Q2. Your occupation: Senior staff, Intermediate staff, Associate Staff, Agricultural entrepreneur, Entrepreneur or private practitioner, Student, Retired, Homekeeper, Unemployed.
Q3. What is your average monthly income without taxes (=gross income)?
Q4. Where do you come from： Asia, Africa, North America, South America, Europe, Oceania.
Q5. Which cross-border e-commerce platforms do you often shop on (You can choose up to 3): Amazon, eBay, AliExpress, Wish, Lazada, Shopee, Alibaba, SHEIN, Dhgate, Light in the box, Banggood, Gearbest, TikTok, Temu, Others.
Q6. How often do you purchase on cross-border e-commerce platforms? Never, Less than once a year, Once or twice a year, Several times a year, About once a month, Two or three times a month, About once a week, Several times a week.
Q7. Which categories of products do you buy the most on these platforms (You can choose up to 3): Arts & Crafts, Automotive, Baby, Beauty & Personal Care, Books, Boys' Fashion, Computers, Digital Music, Electronics, Girls' Fashion, Health & Household, Home & Kitchen, Industrial & Scientific, Kindle Store, Luggage, Men's Fashion, Movies & TV, Music, CDs & Video, Pet Supplies, Software, Sports & Outdoors, Tools & Home Improvement, Toys & Games, Women's Fashion, Others.
Q8. What kind of web interface on the cross-border e-commerce platform website will most attract you to click and browse: Eye-catching titles, Low prices, Beautiful pictures, High praise rate, High sales volume, Brand, Others.
Q9. For the same product on the same cross-border e-commerce platform, what makes you decide to buy products from store A instead of products from store B or C? Lowest price, More detailed product description, Clear video introduction, Higher praise rate, Higher sales volume, Famous brand, Others.
Q10.Which of the following do you think best defines a good product quality? This product functionality meets or exceeds expectations, The service life of this product meets or exceeds the description on the webpage, Very satisfied with the material and appearance of this product, The quality of this product matches the price, Others.
Q11. Do you often have good shopping experience (for example, are you satisfied with the appearance, availability, functionality, service, and so on) on cross-border e-commerce platform: Always (100%), Usually (80%), Often (60%-70%), Sometimes (20%-50%), Hardly ever, Never.
Q12. Do you often purchase the products from the same store, where you had good experience. Always (100%), Usually (80%), Often (60%-70%), Sometimes (20%-50%), Hardly ever, Never.

Appendix 2. Questionnaire 2 (continue)

Questionnaire for analyzing the purchasing behavior of international customers on CBEC platforms
Q13. Do you may be pleasantly surprised to receive an extra thank you note or small gift with your product. Yes, No
Q14. Do you often give feedback on the cross-border e-commerce platform where you purchase: Always (100%), Usually (80%), Often (60%-70%), Sometimes (20%-50%), Hardly ever, Never.
Q15. Do you often give a good review? Always (100%), Usually (80%), Often (60%-70%), Sometimes (20%-50%), Hardly ever, Never.
Q16. Do you often give a negative review? Always (100%), Usually (80%), Often (60%-70%), Sometimes (20%-50%), Hardly ever, Never.
Q17. What to do if you receive poor quality or unsatisfactory products? Return and refund, Only refunds and no returns, Apply for exchange, You don’t deal with it, you consider yourself unlucky, Leave a negative review, You never received poor quality and unsatisfactory products, Others.
Q18. What do you think are the advantages of cross-border e-commerce platforms? You can buy products that are not available locally, The price is favorable and you can wait for a long time for logistics, Good quality and low price, Have developed the habit of frequently shopping on cross-border e-commerce platforms, Others.
Q19. What do you think are the disadvantages of cross-border e-commerce platforms? Slow delivery, Troublesome for return, Troublesome for exchange, The product received does not match the description, Others.
Q20. Overall, are you satisfied with the product quality on cross-border e-commerce platforms? Always, Usually, Sometimes, Never.

Appendix 3. Cover letter for procurement and supply chain experts

Dear respondents,

Thank you for taking the time to participate in our survey! Your opinion is crucial to our dissertation research. The purpose of this survey is to understand the actual contribution value of the entire supply chain management empowered by AI and quality management technology to improve product quality, and we sincerely look forward to your honest answers.

In order to protect your privacy, we promise that this survey will be anonymous and that your personal information will be kept strictly confidential. The entire questionnaire is expected to take about 3 minutes, so please complete it at your convenience.

If you have any questions or need further information during the questionnaire process, please feel free to contact us at any time.

Email: xiulin.qiu@edu.turkuamk.fi

Name: Xiulin Qiu

School: Turku University of Applied Sciences.

Your feedback will be highly valued. Thank you again for your participation and I look forward to hearing your valuable feedback! Thank you!

Appendix 4. Cover letter for international customers

Dear respondents,

Thank you for taking the time to participate in our survey! Your opinion is crucial to our thesis research. The purpose of this survey is to understand the purchase habits of international customers on cross-border e-commerce platforms and their satisfaction with product quality, and we sincerely look forward to your honest answers.

In order to protect your privacy, we promise that this survey will be anonymous and that your personal information will be kept strictly confidential. The entire questionnaire is expected to take about 3 minutes, so please complete it at your convenience.

If you have any questions or need further information during the questionnaire process, please feel free to contact us at any time.

Email: xiulin.qiu@edu.turkuamk.fi

Name: Xiulin Qiu

School: Turku University of Applied Sciences.

Your feedback will be highly valued. Thank you again for your participation and I look forward to hearing your valuable feedback! Thank you very much!

Appendix 5: The first ten cleaned and sorted data

Age	40-49 years old	18-29 years old	30-39 years old	30-39 years old	30-39 years old	40-49 years old	18-29 years old	30-39 years old	18-29 years old	30-39 years old
Occupation	Senior staff	Entrepreneur or private practitioner	Unemployed	Senior staff	Senior staff	Student	Associate Staff	Intermediate staff	Intermediate staff	Student
Salary	2600	2500	1000	3200	12000	700	1800	3000	1800	0
Country	Asia	Asia	Asia	Asia	Asia	Asia	Asia	Europe	Europe	Europe
Platforms	Temu	Boozt	SHEIN	Temu	Taobao	Amazon	Amazon	Others	SHEIN	Amazon
Frequency	About once a month	Several times a year	Several times a year	Once or twice a year	Less than once a year	Several times a year	Once or twice a year	Less than once a year	Less than once a year	Once or twice a year
Categories	Women's Fashion	Women's Fashion	Home & Kitchen	Women's Fashion	Electronics	Home & Kitchen	Tools & Home Improvement	Others	Women's Fashion	Home & Kitchen
Attract highlights	Low prices	Beautiful pictures	High praise rate	High praise rate	High praise rate	High praise rate	Brand	Brand	Beautiful pictures	Low prices
Determining factors	More detailed product description	Famous brand	Lowest price	More detailed product description	Higher praise rate	Higher praise rate	Famous brand	Famous brand	More detailed product description	Higher praise rate
Good product definition	This product functionality meets or exceeds expectations	The quality of this product matches the price	The service life of this product meets or exceeds the description on the webpage	The quality of this product matches the price	The service life of this product meets or exceeds the description on the webpage	The service life of this product meets or exceeds the description on the webpage	This product functionality meets or exceeds expectations	The quality of this product matches the price	This product functionality meets or exceeds expectations	The service life of this product meets or exceeds the description on the webpage
Good experience	Usually (80%)	Usually (80%)	Usually (80%)	Often (60%-70%)	Sometimes (20%-50%)	Sometimes (20%-50%)	Usually (80%)	Hardly ever	Usually (80%)	Often (60%-70%)
Same store	Usually (80%)	Usually (80%)	Usually (80%)	Usually (80%)	Sometimes (20%-50%)	Sometimes (20%-50%)	Usually (80%)	Often (60%-70%)	Usually (80%)	Usually (80%)
Surprised to get extra	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Feedback	Sometimes (20%-50%)	Sometimes (20%-50%)	Sometimes (20%-50%)	Often (60%-70%)	Hardly ever	Hardly ever	Never	Often (60%-70%)	Never	Hardly ever
Good review	Often (60%-70%)	Usually (80%)	Usually (80%)	Often (60%-70%)	Often (60%-70%)	Often (60%-71%)	Never	Sometimes (20%-50%)	Never	Hardly ever
Negative review	Sometimes (20%-50%)	Hardly ever	Never	Sometimes (20%-50%)	Sometimes (20%-50%)	Sometimes (20%-51%)	Never	Often (60%-70%)	Never	Hardly ever
Poor quality	You don't deal with it, you consider yourself unlucky.	Return and refund	Return and refund	Return and refund	Return and refund	Return and refund	You never received poor quality and unsatisfactory products	Return and refund	Return and refund	Return and refund
Advantage	The price is favorable and you can wait for a long time for logistics	Good quality and low price	You can buy products that are not available locally	Good quality and low price	Good quality and low price	Good quality and low price	You can buy products that are not available locally	Good quality and low price	You can buy products that are not available locally	You can buy products that are not available locally
Disadvantage	Troublesome for return	Troublesome for exchange	The product received does not match the description	Troublesome for return	Troublesome for return	Troublesome for exchange	Slow delivery	Slow delivery	The product received does not match the description	Troublesome for return
Satisfying	Usually	Usually	Usually	Usually	Usually	Sometimes	Usually	Sometimes	Usually	Usually