



QUALITY MANAGEMENT OF E-BUSINESS: A KEY NODE ANALYSIS OF ECOLOGICAL NETWORK IN DIGITAL ECONOMY BY USING ARTIFICIAL INTELLIGENCE¹

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Abstract

The development of the E-business market has greatly encouraged the companies to be involved in online competition. Quality management has therefore become an important

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issue for the E-business companies in digital economy. The quality management on the E-business market can be helpful for the development of fair market competition, and is also of a great necessity for the improvement of brand equity and core competitiveness of the E-business companies. This paper investigates the ecological network in quality management based on information provided by quality management cases. The research further reveals the dynamic market structure of the competition between the certified products and the falsely branded products. The mutation algorithm is performed to identify the key nodes of cases involved in the ecological network of quality management issues on the E-business market. The ant colony optimization is further performed to control and regulate the key nodes in quality management on the E-business market. This research offers support to quality management of E-business based on ecological network by using artificial intelligence in digital economy and digital trade.

Keywords: E-business, quality management, ecological network, artificial intelligence

JEL Classification: F23, M31, L15, L81

Introduction

The quality management work of E-business has become an important issue for the business administrators of the E-business companies. E-business has become an important market for the companies to compete in the global expansion. While the E-business market is upgrading the manufacturing of products, the distorted use of trades and patents as well as the falsely branded products bring negative effects on the development of the market. The quality management of E-business products on the online consumption market is of great importance. Lai & Wang (2014) also pointed out that the quality management of the E-business market can be further enhanced, and the complaints about the false advertising and the falsely labeled products are still in need of being further managed. The complaints about the falsely labeled products may have negative effect on the branding of E-business companies on the oversea markets. Lai *et al.* (2013) pointed out that the foreign online consumers prefer to offer feedbacks on the E-business market, and are also more likely to make suggestions and comments to the follower consumers of the E-business market. Therefore, the quality management of the E-business products can offer a great support to brand development in the foreign markets.

Falsely branded products have negative effects on the brand image of the E-business companies. The falsely branded products highly affect the brand image of products on the global E-business market and further harm the competitiveness of the E-business companies operating and developing on global markets. Tang & Lu (2010) pointed out that the falsely branded products have unverified quality in relation to the original brands, and the lack of quality specifications has negative effect on the consumption attitude of the online buyers. Wang (2011) pointed out that the development of E-business provides support for the improvement of competitiveness of the E-business companies, creates increased opportunities for international business, leads to a decreased cost in operations, and further enhances a good image of such companies. However, the manufacturing and sales of falsely branded products in E-business marketing activities breaks the fairness of market competition, and have negative effects on the brand image of the E-business companies. Sun (2014) pointed out that vendors and buyers in the cross-border E-business market have different cultural and geographical backgrounds, and the credit is often one of the key

determinants that facilitates a deal. The falsely branded products can induce to the foreign online buyers a rejecting attitude towards the manufacturer, which further affects the brand development of the E-business companies through a long-term effect. Therefore, the quality management of E-business products has a great importance for the E-business companies.

Literature Review

The motivation that leads to falsely branded products in the E-business market can be identified as being based on several factors. The virtual business environment creates a context for the falsely branded products. The information asymmetry offers support to the market development of the falsely branded products. The online crediting system also can be further developed to prevent the survival of falsely branded products. The learning experiences of online consumers can be further developed to identify the falsely branded products. The competition among the E-business companies can also be further organized to avoid the opportunism by falsely branded products.

1. Quality Management of E-business in the Virtual Environment

The falsely branded products take advantage of the virtual environment on the E-business market for online promotions and communications. The online sellers can take the advantage of false description and false advertising, and replace the ordered categories with falsely branded products. Different from the face-to-face transactions, the online sellers can take advantage of the virtual condition in the online ordering activities, and the high difficulty of quality management of online sales activities is further increased on the E-business market. Zhai (2013) pointed out that the manufacturing and selling activities of falsely branded products on the E-business market, as well as the false advertising of products, affect the regulation of E-business market and harms the business credit in E-business operations, by taking advantages of the virtual condition, open environment, and the cross-regional attributes of E-business. The quality management of E-business market and prevention of falsely branded products are of great necessity for the future development of E-business market.

2. Quality Management of E-business in Information Asymmetry

The falsely branded products take advantage of the information asymmetry in order to develop on the market. Chen (2011) pointed out that the information asymmetry still exists in the E-business market, and it is difficult to make a clear identification between high-quality and low-quality products merely based on the business performance and product descriptions. The expectations of the online consumers based on the average level of quality can be important determinants for the accepted price and purchase decisions. Therefore, the higher quality products can be forced to quit the market due to limited price and shrink margins, which leads to an increasing issue of "fake products" problem and to adverse selection on the E-business market. Bomsel (2014) pointed out that the falsely branded products take a 'free ride' by the brand awareness of well-known brands, and make false descriptions of product functions and specialty, which greatly affects the attitude of online consumers and the brand image of the E-business companies. The result can be even worse when the customer loyalty to the well-known brands and the purchase decisions are further distorted.

3. Quality Management of E-business with Crediting Systems

The online crediting system can be further developed to prevent the survival of falsely branded products. Xie (2014) pointed out that the evaluation system of the E-business market is currently dependent on the third-party E-business operators, and the quality

management can rely on their regulation, whose control power on the E-business companies can be further enhanced. Also, the crediting system of E-business market can be further developed, and the evaluation is expected to fulfil the needs of cross-border online business activities. Lu (2011) pointed out that a mutual trust can be a good foundation for the online transactions between buyers and suppliers. The evaluation of online crediting and regulation of quality management can be enhanced, to further develop the mutual trust on the E-business market, and to avoid the sales of falsely branded products. Kwok *et al.* (2010) pointed out that the RFID technology added to the EPC regulation network can be applied to develop the regulation system of online products in the global supply chains and distribution networks. Together with the online information system and inter-connected product database, the global distribution networks can be further upgraded to prevent that the falsely branded products are mixed with the good ones.

4. Quality Management of E-business with Learning Experience

The learning experiences of the online consumers can be further developed in quality management and in the attempts to avoid the falsely branded products. The reasons that lead the online consumers to order falsely branded products can be related to the virtual satisfaction of such customers. The opportunism for a margin of online sales activities that target at consumer satisfaction in online shopping can also lead to the online sales of falsely branded products. Bian & Moutinho (2011) pointed out that the preference for well-known brands can be an important reason that leads to the purchasing of falsely branded products on the global market. Liao & Hsieh (2013) also pointed out that consumers usually make purchase of falsely branded products due to unfamiliarity and limited experiences in the cellphone market. Also, the sales activities of falsely branded products offer support to the manufacturing of such products, and thus the manufacturers, sellers and buyers of falsely branded products are inter-connected with each other.

5. Quality Management of E-business with Market Competition

The competition among the E-business companies also provides rising favorable circumstances to the falsely branded products. The E-business companies are involved in a market competition of high level. Therefore, the E-business companies can be further regulated for organized market operations. Also, the regulation of third-party E-business operators can be further enhanced in quality management. The involvement of E-business operators can be further developed in quality management to the online consumption activities. Zhi & Wang (2013) pointed out that a further evaluation of third-party E-business operators can be important for the regulation of online transactions, development of buyer learning experience, and prevention of falsely branded products in quality management.

Therefore, the quality management of E-business market can be an important issue for the future development of E-business companies, and is of a great necessity for the development of brand image of the E-business companies. The Cournot equilibrium and Stackelberg equilibrium may be applied to analyze the gaming in market competition between high quality products and falsely branded products, and Ding and Qi (2011) analyzed the market competition in negotiation of prices of iron ore products based on these types of equilibria. This research further develops the analysis of market competition between certified products and falsely branded products by importing the effect of penalty to falsely branded products in the market competition based on the Cournot equilibrium and the Stackelberg equilibrium.

The sale of falsely branded product is set as $Q_1 = \sum_{i=1}^{N_1} q_i$, and the sale of certified products is set as $Q_2 = \sum_{j=1}^{N_2} q_j$.

The price elasticity of falsely brand products is e , and the price elasticity of certified products is b . The price of the product market is:

$$P = a - (eQ_1 + bQ_2) = a - (e \sum_{i=1}^{N_1} q_i + b \sum_{j=1}^{N_2} q_j)$$

When the competition among the certified products reaches the Cournot equilibrium, with marginal cost of certified products as c_j , the interconnection of sale for certified products q_j^*

and sale for falsely branded products q_i^* is: $q_j^* = \frac{a - c_j - eN_1q_i^*}{b(N_2 + 1)}$

The falsely branded products and certified products gradually reach the Stackelberg equilibrium, and the sale of falsely branded products may follow the sale of certified products. When the competition among the falsely branded products also reaches the Cournot equilibrium, with marginal cost of falsely branded products as c_i and the penalty of the falsely branded products as f , the sale of falsely branded products in equilibrium is:

$$q_i^* = \frac{(a - c_i) + N_2(c_j - c_i) - f(1 + N_2)}{e[1 + N_1 + N_2 + (1 - 2b)N_1N_2]}$$

And the sale of certified products in equilibrium is:

$$q_j^* = \frac{(a - c_j)[1 + N_1 + N_2 + (1 - 2b)N_1N_2] - (N_1 + N_2)(c_j - c_i) + f(1 + N_2)}{b(1 + N_2)[1 + N_1 + N_2 + (1 - 2b)N_1N_2]}$$

The penalty of falsely branded products can have a negative effect on the sale of falsely branded products. Also, the penalty of falsely branded products can have a positive effect on the sale of certified products. The key issue in quality management of the E-business market will also be the identification of key nodes working as falsely branded products in the ecological network that highly motivate other falsely branded products to be involved in the market competition. The quality management can be enhanced under the circumstance that the key nodes of falsely branded products are controlled and regulated by a high level of penalty, and other falsely branded products are unwilling to be involved in the market competition and to pay a high level of penalty in similar cases.

The current researches studied the attributes of E-business market, information asymmetry of online consumption, development of online crediting system, development of learning experience by online consumers, and market competition among the E-business companies as important factors that influence the control of falsely branded products. Researches of quality management in the E-business market have focused on the trade-offs in regulation across different parties, and the factors that influence online consumer behavior in referring to falsely branded products. The research of key nodes in ecological network of quality management issues in E-business can be further developed to offer support to quality management of the E-business market.

Research Method

The research of quality management in the E-business market has been primarily focused on the game theory models that analyze the interest trade-offs across different parties in the sales of falsely branded products. Du (2008) applied the game theory model to analyze the

information asymmetry of consumer, regulator, and sellers on the E-business market. Yin & Cui (2012) also analyzed the payoff matrix of sellers of falsely branded products. There are also researches that analyzed the online consumer behavior of falsely branded products. Muthiani & Wanjau (2012) analyzed the brand awareness, pricing strategy, and potential risks as factors that influence the sales of falsely branded pharmaceutical products. Hendriana *et al.* (2013) also analyzed the effect of culture, product quality, and emotions in movie ticket purchasing activities by college students. Tong (2010) pointed out that consumers usually prefer to make online purchase due to conveniences by E-shopping, and it is suggested that regulations of the third-party E-business operators frequently accessed by online consumers can be further enhanced. Jin (2012) also found that the online consumers can be influenced by social and mediate reference groups, and it is suggested that verbal effect and internet communication are important for the market development of E-business companies.

This research analyzed the cases involved in quality management issues on the E-business market. The ecological network is studied based on attributes of complaints and defendants, locations of cases, time period of cases, and industry involved in quality management, complaint issues in quality management, involvement of E-operators. The cases are collected from the pkulaw database. The dynamic market structure in the competition between certified products and falsely branded products is simulated. The mutation algorithm is performed to identify the key nodes of cases involved in ecological network of quality management on the E-business market. The ant colony optimization is further performed to enhance the control and regulation of key nodes in ecological network of quality management on the E-business market.

Result

The interconnections of E-business cases with reference to quality management issues are studied in the research, based on the identity of the complaint and response, the location of quality management issue for digital market, the time period for the quality management issue to be delivered for settlement, the industry that the E-business cases are involved in, the reasons that the quality management refers to in digital market, and the involvement of E-operators in the quality management issue. E-business cases are studied for analyzing the structure of ecological network in quality management issues at digital market.

1. Analysis of Species Competition in the Ecological Network of E-business

In the ecological network, the competition of species can be a dynamic performance based on the gaming of species in survival. The enforcement of competitiveness for one species provides a stress to the survival of its competitor species. The quality management of E-business can be analyzed following the discussions of ecological network of different products. The certified products and falsely branded products can be treated as two competitor species in the ecological network of the E-business market. In the case that growth of certified products and falsely branded products can induce stress in each other, the differentiation of sale performance for the certified products can be:

$$\frac{d\alpha}{dt} = r_1\alpha\left(1 - \frac{\alpha}{n_1} - s_1\frac{\beta}{n_2}\right)$$

The $\alpha_{(t)}$ represents the sale performance of certified products, and $\beta_{(t)}$ represents the sale performance of falsely branded products. The r_1 represents the growth rate of sale of certified products. The n_1 represents the total number of certified products, and n_2 represents the

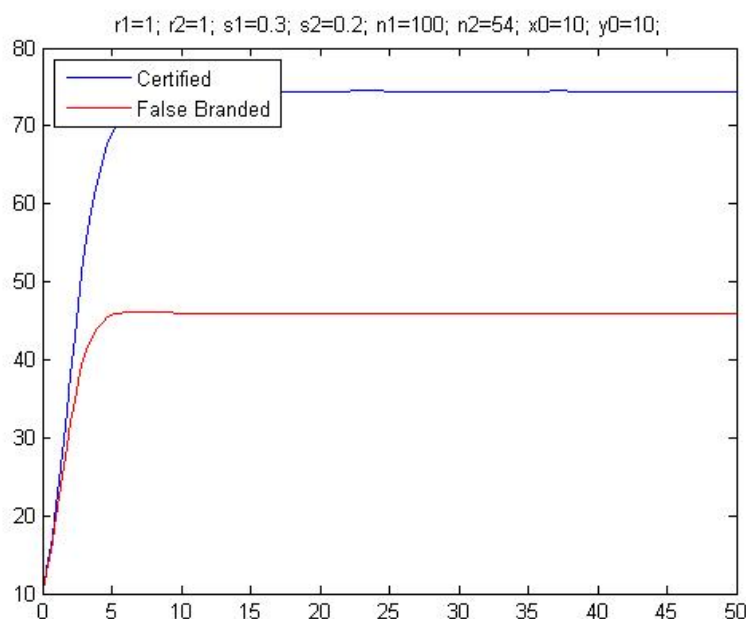
total number of falsely branded products. The s_1 represents the multiplier of unit consumption for falsely branded products in comparison to unit consumption for certified products. Furthermore, the r_2 can be set to represent the growth rate of sale for falsely branded products, and s_2 can be set to represent the multiplier of unit consumption for certified products in comparison to unit consumption for falsely branded products. The differentiation of sale performance for the falsely branded products can be:

$$\frac{d\beta}{dt} = r_2\beta\left(1 - s_2\frac{\alpha}{n_1} - \frac{\beta}{n_2}\right)$$

If $s_1 < 1$, and $s_2 < 1$, the enforcement of growth power for either certified products or falsely branded products can hardly make one product outperform the other in an efficient way. In this case, the growth of certified products and falsely branded products is shown in Figure 1. The $s_1=0.3$, and $s_2=0.2$, and the growth of certified products increases to a higher level than the growth of falsely branded products. However, it is difficult for the certified product to restrain the survival of falsely branded products.

Figure 1

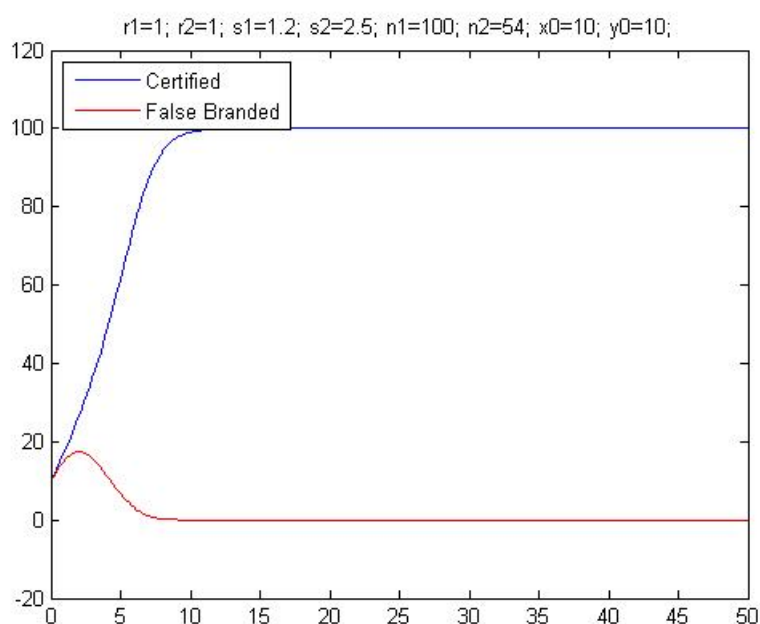
**Competition of Certified Products and Falsely Branded Products
($s_1 < 1, s_2 < 1$)**



If $s_1 > 1$, and $s_2 > 1$, the enforcement of growth power for either certified products or falsely branded products is likely to make one product outperform the other in an efficient way. In this case, the growth of certified products and falsely branded products is shown in Figure 2. The $s_1=1.2$, and $s_2=2.5$, and it is shown that the growth of certified products can be a restraint for the survival of falsely branded products. The sale performance of falsely branded products can be decreased by the growing sale performance of certified products.

It is possible that the effect of penalty to falsely branded products in the ecological network of the E-business market can be a restraint to the survival of falsely branded products in competition with the certified products. The increased penalty and enhanced regulation to falsely branded products can offer to the certified products an advantage to restrain the survival of falsely branded competitors in quality management on the E-business market.

Figure 2
Competition of Certified Products and Falsely Branded Products ($s_1 > 1$, $s_2 > 1$)



2. Key Node in Quality Management of E-business based on Ecological Network

The identity between complaint and defendant includes the C2C complaint and P2C complaint issues. The C2C cases have both complaint and defendant from companies involved in the E-business quality management, and the P2C cases have the complaint referring to online consumption made by private customers to companies on the E-business market. The complexity issue of E-business complaints refers to the roles involved in the issue. Furthermore, different locations where the complaint take places are also analyzed, including the locations of BJ, SH, GD, ZJ, JS, and other locations. The industries for each case involved in have also been analyzed, including fashion, food, electronic appliances, and other life uses. The time period of the cases delivered for settlement ranged from year 2013 to year 2016, and also cases delivered for settlement before the year of 2012. In addition, the involvement of E-operators in the quality management issue is also analyzed. The reasons of the complaints in E-business market include the issues in referring to trademarks, copyrights, patents, quality, and false description of the products.

The mutation algorithm is performed for identification of key nodes based on cases involved in quality management issues on the E-business market. The identification of key nodes in the ecological network of quality management issues can be helpful to enhance the regulation of falsely branded products. The restraint and prevention of key nodes in the ecological network can be important in controlling the network effect of falsely branded products on the E-business market. Also, the penalty and control of key nodes in the ecological network can offer further warnings to followers of falsely branded products. The information of cases involved in quality management issues are coded on the basis of complaint entities, complaint time period, complaint location, and also industry involvement, quality management issues, E-operator involvement. The centrality of cases is controlled in the identification of key nodes. The centrality of cases in the ecological network is analyzed based on the case information by 2-mode network, as follows:

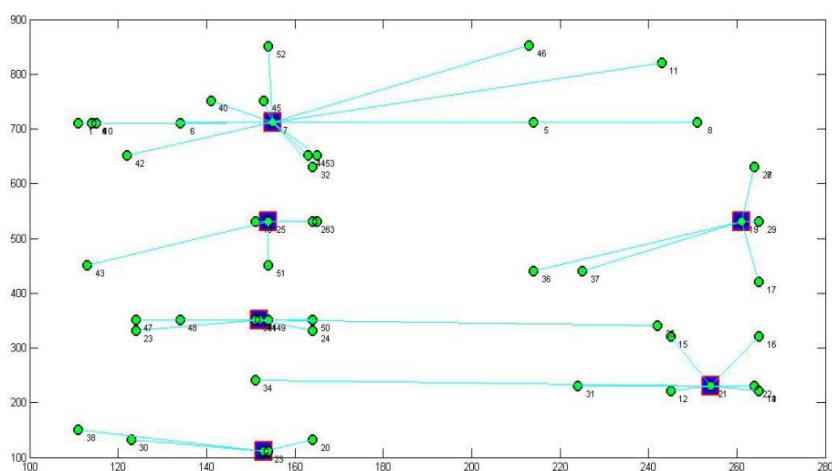
$$C_c^{NM}(n_i) = \left[1 + \frac{\sum_{j=1}^{g+h} \min d(k, j)}{k} \right]^{-1}$$

The centrality of node n_i in the 2-mode network based on the information of cases involved in quality management is measured on the basis of distance across the different nodes and case information.

The g represents the number of nodes, and h represents the attributes of node case information, while case information k is connected to node n_i . The mutation algorithm in identification of key nodes in ecological network of cases involved in quality management at E-business market is performed in Figure 3.

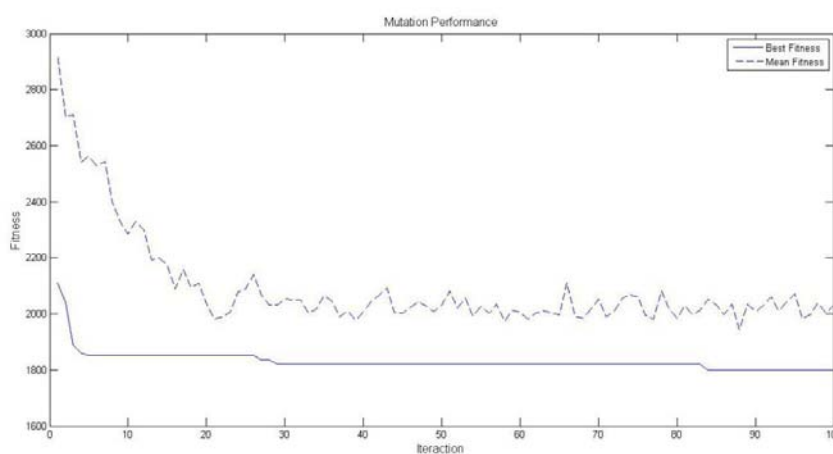
Figure 3

Key Nodes in Ecological Network of Quality Management based on Mutation Algorithm



The key nodes in ecological network of cases involved in the quality management issues include node₂, node₇, node₁₉, node₂₁, node₂₅, and node₅₄. The performance of mutation algorithm in identification of key nodes in cases involved in quality management is shown in Figure 4. It is found that the best fitness and mean fitness becomes convergent as the mutation algorithm is performed.

Figure 4
Performance of Mutation Algorithm in Identification of Key Nodes of Cases Involved in Quality Management Issues



Furthermore, the interconnections of case nodes to the identified key nodes in the ecological network of quality management on the E-business market is further revealed by chord diagram in Figure 5. The interconnections of case nodes following the key nodes in the chord diagram are shown in groups based on the attributes of case information involved in the quality management.

1. Quality Management of E-business by Using Ant Colony Optimization

The quality management of E-business is further processed by ant colony optimization to avoid the key nodes of cases involved in quality management issues. The path of ant colony optimization is shown in Figure 6. The black spots are case nodes interconnection to key nodes involved in quality management issues, and the path of the quality management is controlled by ant colony optimization to avoid the key nodes of cases involved in quality management issues. The artificial intelligence of quality management in online retailing, distribution services, and consumer reference can offer important support to the regulation and supervision of the E-business market.

Figure 5
Chord Diagram of Case Nodes Involved in Quality Management Issues

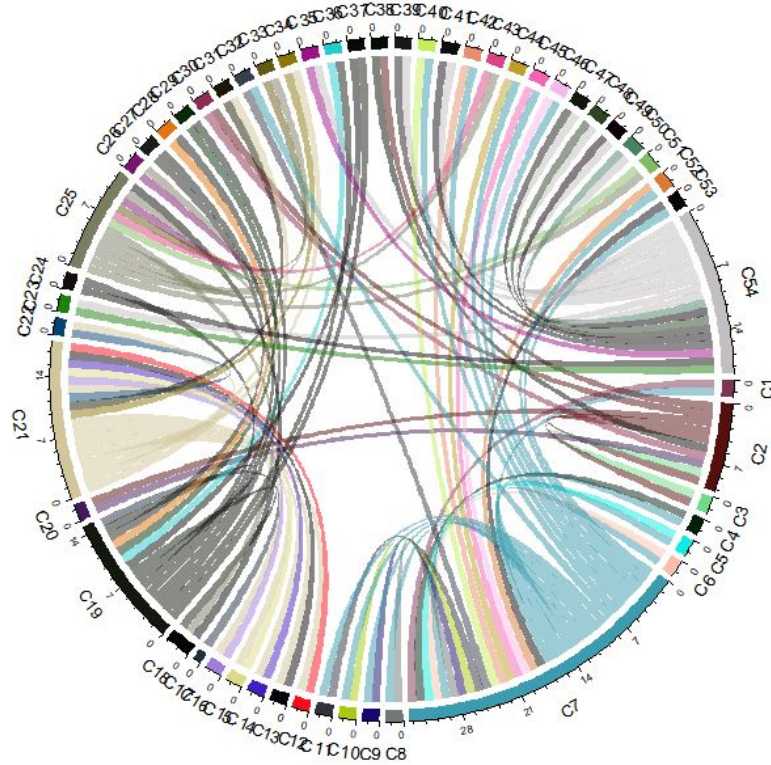
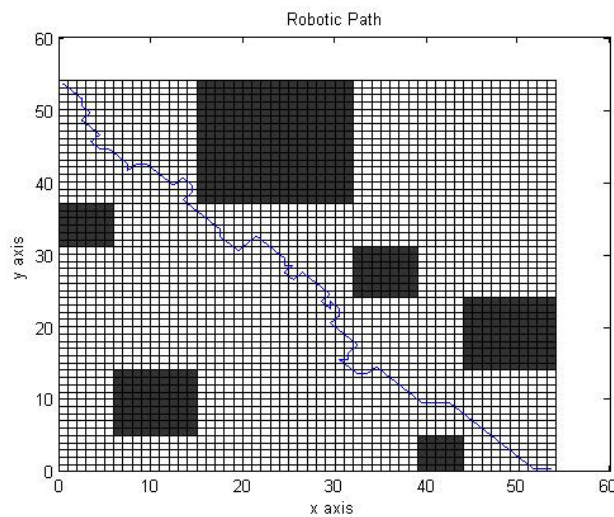


Figure 6
Quality Management of E-business by Using Ant Colony Optimization



Conclusion

The quality management has become an important issue for the E-business companies as the market has developed greatly. The quality management of the E-business market can be analyzed in an ecological network based on case information covering multiple issues involved in quality management. This research analyzes the market competition between certified products and falsely branded products in the ecological network of the E-business market based on Cournot equilibrium and Stackelberg equilibrium. The effect of penalty and regulation of falsely branded products is suggested to be helpful to quality management in the ecological network of the E-business market. The enhanced penalty and regulation of falsely branded products may be an important support to the certified products in the market competition, and also delivers a warning message to followers of falsely branded products.

The dynamic market structure in the competition between certified products and falsely branded products is further analyzed in the ecological network. The enhanced penalty and regulation of falsely branded products offers to the certified products a higher growth power in the competition on the E-business market. In the inter-species competition of an ecological network, it is suggested that the growth of one species affects the survival of other species. When the growth of certified products and growth of falsely branded products mutually affect each other at a lower and similar level, the growth of certified products may find it hard to restrain the growth of falsely branded products. When the growth of certified products and growth of falsely branded products mutually affect each other at a higher but different level, the growth of certified products is more likely to restrain the survival of falsely branded products. The enhanced penalty and regulation of falsely branded products is suggested to increase the difference of growth power between certified products and falsely branded products, and to further increase the power of the certified products to restrain the survival of falsely branded products. The dynamic market competition between certified products and falsely branded products in the ecological network of quality management on the E-business market is further simulated.

The identification of key nodes of cases involved in the ecological network of quality management offers further support for the enhancement of regulation of the E-business market. The enhanced penalty and regulation of key nodes of cases involved in quality management issues on the E-business market may offer important support to the growth of certified products and restrain the survival of falsely branded products. The mutation algorithm is performed to identify the key nodes of cases involved in quality management issues on the E-business market based on case information on complaint entity, complaint time period, complaint location, and industry involved in quality management, issues involved in quality management, E-operator involved in quality management. The key node analysis can be an important way for quality management on the E-business market. The key node analysis can be helpful to identify the key nodes of cases involved in the ecological network of quality management issues, and further enhance the regulation of E-business market.

The quality management is further performed by ant colony optimization, in order to avoid the case nodes connected to key nodes in quality management issues on the E-business market, and the falsely branded products are further regulated in the quality management of the ecological network. The key nodes of cases involved in the ecological network of quality management issues are further controlled, and the falsely branded products are further prevented in the quality management by ant colony optimization. The key node analysis in

ecological network by using artificial intelligence offers support to quality management of E-business market in the digital economy and digital trade.

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