Evolutionary Game Analysis for the Regulation of Merchants Selling Counterfeits on E-commerce Platforms

Lifang Le[1,*]

[1]Business Administration Department, Chongqing Technology and Business University, 400067, Chongqing, China.

Abstract: In recent years, the phenomenon of merchants selling counterfeits has occurred frequently, exposing the lack of supervision by government and e-commerce platforms. In order to solve the problem of merchants selling counterfeits on e-commerce platforms, this paper takes the governments, e-commerce platforms and consumers as the regulatory participants, building a tripartite evolutionary game model, obtaining the system evolutionary equilibrium point, analyzing the equilibrium point and its stability, and finally providing corresponding countermeasures and suggestions for the supervision of merchants selling counterfeits on e-commerce platforms.

1 Introduction

With the rapid development of the Internet, the network economy dominated by e-commerce is changing the traditional business model. Online shopping has a blowout growth, and e-commerce platforms are playing an important role in promoting e-commerce. However, the phenomenon of merchants selling fake goods has also become increasingly prominent.

The problem of merchants selling counterfeits has always been a hot topic of research, and scholars at home and abroad have conducted in-depth research on it. Most scholars believe that it is mainly caused by information asymmetry, consumers cannot grasp quality information like merchants [1], and e-commerce platforms have low threshold for merchants, weak platform supervision, and low cost for merchants to sell fake goods [2-3]. The cost of supervision and the intensity of punishment are very important factors influencing the supervision of sellers selling counterfeits. Reducing the cost of supervision and increasing the intensity of punishment can effectively solve the problem of merchants selling fake goods [4-5]. In addition, it is not enough to rely only on the supervision of a single subject, which requires the participations of multiple parties such as the governments and e-commerce platforms. Zhang analyzed the game of product quality supervision between e-commerce platforms and product producers [6]. Si took the genuine manufacturers and the counterfeit enterprises as game players and analyzed that government-enterprise cooperation mechanism can crack down on counterfeit behaviors [7].

To sum up, in terms of the regulation of sellers' counterfeit behaviors, few scholars have considered the dynamic game among the governments, e-commerce platforms and consumers, as well as the influence of different conditions on the regulation of merchants' counterfeit behaviors. Therefore, this paper constructs an evolutionary game model to analyze the strategy choices of participants in the regulation of merchants selling counterfeits under different circumstances.

2 Model assumptions and construction

2.1 Basic assumptions of the model

In the supervision mechanism of merchants selling counterfeits on e-commerce platforms, this paper sets up three participants: government, e-commerce platform and consumer. The logical relationship of the game model constructed in this paper is as follows:

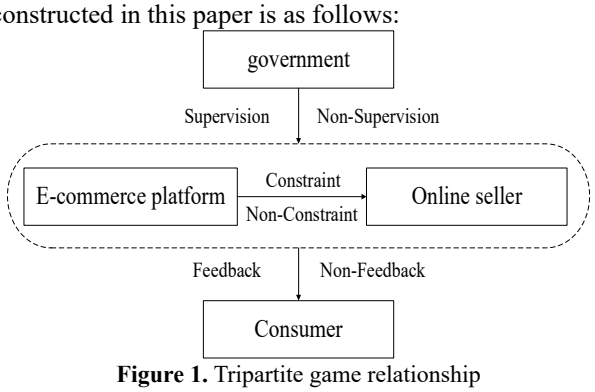

Figure 1. Tripartite game relationship

Assumption1： All three players are limited rationality; when one player makes a strategy adjustment, the other players will make the adjustment simultaneously.

Assumption2: Government is player 1, e-commerce platform is player 2, and consumer is player 3. players all

* Corresponding author: lelifang98@163.com

adopt two strategies and make decisions independently of each other. The strategy set of the government is {supervision, non-supervision}, and the probability is $x(0 \le x \le 1)$, and $1-x$, respectively. The strategy set of e-commerce platforms is {constraint, non-constraint} and the probability is $y(0 \le y \le 1)$, and $1-y$, respectively. The strategy set of consumer is {feedback, non-feedback} and the probability is $z(0 \le z \le 1)$, and $1-z$, respectively.

2.2Model construction

Based on the principle of profit maximization, all participants will make the best decision. In supervision mechanism of merchants counterfeiting, the e-commerce platform is responsible for restraining merchants selling counterfeits, supervising the quality of products sold by merchants, and handling consumers' complaints against merchants. If e-commerce platform fails to fulfill its duty, it will be punished by government. This paper summarizes the variables and parameters used to construct the tripartite game model, which is shown in table 1. Based on the above basic assumptions and the variables and parameters in table 1, this paper constructs the tripartite payoff matrix of the government, e-commerce platform and consumer. The payoff matrix is shown in table 2.

Table 1. The meaning of the variables and parameters in the tripartite game model

Symbols	Description
P_g	Social benefits of regulation strategy adopted by the government.
C_g	Regulation cost of regulation strategy adopted by the government.
F_g	Punished by superior departments of non-regulation strategy adopted by the government.
R	Basic income of daily operation of e-commerce platform.
R_1	Additional earnings of restraint strategy adopted by the e-commerce platform.
R_2	Additional earnings of non-restraint strategy adopted by the e-commerce platform.
B_P	Government incentives of restraint strategy adopted by the e-commerce platform.
C_p	The cost of restraint strategies adopted by e-commerce platform.
F_p	Punished by government of non-restraint strategy adopted by the e-commerce platform.
D_p	Reputation loss caused by consumer complaints when e-commerce platforms adopt unconstraint.
M_1	The value of information obtained by consumers when the government releases sampling inspection results and trust-breaking lists on the regulatory information platform.
M_2	The value of information obtained by consumers when the e-commerce platforms publish merchants reputation and review results on regulatory information platforms.
M	The value of information obtained by consumers when government regulatory departments and third-party e-commerce platform release information at the same time. $(M = M_1 + M_2)$
L	Losses incurred by consumers receiving fake goods.
G	E-commerce platform compensation when consumers successfully complain.

Table 2. The tripartite payoff matrix for the regulation of merchants selling counterfeits

Game player				E-commerce platform	
				Constraint	Non-constraint
Government	Supervision	Consumer	Feedback	$P_g - C_g - B_p$ $R + R_1 + B_p - C_p$ $M - f$	$P_g - C_g + F_p$ $R + R_2 - F_p - D_p$ $M_1 - f$
			Non-feedback	$P_g - C_g - B_p$ $R + R_1 + B_p - C_p$ M	$P_g - C_g + F_p$ $R + R_2 - F_p$ M_1
	Non-Supervision	Consumer	Feedback	0 $R + R_1 - C_p$ $M_2 - f$	$-F_g$ $R + R_2 - D_p$ $G - L - f$
			Non-feedback	0 $R + R_1 - C_p$ M_2	$-F_g$ $R + R_2$ $-L$

The dynamic replication equations of the government, e-commerce platforms and consumers are as follows:

$$F(x) = -x(1-x)[C_g - P_g + yB_p - (1-y)(F_g + F_p)] \quad (1)$$

$$F(y) = y(1-y)[R_1 - R_2 - C_p + x(B_p + F_p) + zD_p] \quad (2)$$

$$F(z) = -z(1-z)[f - G(1-x)(1-y)] \quad (3)$$

3 Evolutionary stability strategy analysis

The stability analysis of equilibrium point in tripartite evolutionary game can be judged according to Lyapunov indirect method. To further obtain the stable equilibrium point, Jacobian matrix is used for analysis.

Set the dynamic replication equations: F(x)=F(y)=

F(z)=0, then 8 equilibrium points can be obtained by using MATLAB: E_1 (0,0,0), E_2 (1,0,0), E_3 (0,1,0), E_4 (0,0,1), E_5 (1,1,0), E_6 (1,0,1), E_7 (0,1,1), E_8 (1,1,1).

According to Lyapunov indirect method, if matrix eigenvalues are all less than 0, then the point is evolutionary stable strategy, namely ESS.

Table 3. Stability analysis of equilibrium point of game system

Equilibrium point	Eigenvalues	Case 1: R_1-C_p-R_2>0			Case 2: R_1-C_p-R_2<0		
		Sym-bol	Conditions	Attributes	Sym-bol	Conditions	Attributes
$E_1(0,0,0)$	$G-f$ $R_1-C_p-R_2$ $F_g-C_g+F_p+P_g$	+ + **	/	Unstable point	+ - **	/	Unstable point
$E_2(1,0,0)$	$-f$ $C_g-F_g-F_p-P_g$ $B_p+F_p+R_1-C_p-R_2$	- ** +	/	Unstable point	- ** **	Condition 3	ESS
$E_3(0,1,0)$	$-f$ $C_p-R_1+R_2$ $P_g-C_g-B_p$	- - **	Condition 1	ESS	- + **	/	Unstable point
$E_4(0,0,1)$	$f-G$ $D_p+R_1-C_p-R_2$ $F_g-C_g+F_p+P_g$	- + **	/	Unstable point	- ** **	Condition 4	ESS
$E_5(1,1,0)$	$-f$ $C_g+B_p-P_g$ $-B_p-F_p-R_1+C_p+R_2$	- ** -	Condition 2	ESS	- ** **	Condition 5	ESS
$E_6(1,0,1)$	f $C_g-F_g-F_p-P_g$ $B_p+D_p+F_p+R_1-C_p-R_2$	+ ** +	/	Unstable point	+ ** **	/	Unstable point
$E_7(0,1,1)$	f $P_g-C_g-B_p$ $C_p-D_p-R_1+R_2$	+ ** -	/	Unstable point	+ ** **	/	Unstable point
$E_8(1,1,1)$	f $C_g+B_p-P_g$ $C_p-B_p-D_p-F_p-R_1+R_2$	+ ** -	/	Unstable point	+ ** **	/	Unstable point

Note: ** indicates the positive or negative uncertainty of the symbol.

Condition 1: P_g-C_g-B_p<0; Condition 2: B_p+C_g–P_g<0;
Condition 3: C_g-F_g-F_p-P_g<0 and B_p+F_p+R_1-C_p-R_2<0;
Condition 4: D_p+R_1-C_p-R_2<0 and F_g-C_g+F_p+P_g<0;
Condition 5: B_p+C_g–P_g<0 and B_p-F_p-R_1+C_p+R_2<0.

If there are positive eigenvalues, it is an unstable point. Combined with the existing conditions, the analysis of equilibrium points is divided into case 1 (R_1-R_2-C_p>0) and case 2 (R_1-R_2-C_p<0). The results are shown in table 3.

Under certain conditions, the evolutionary game for regulation system of merchants counterfeiting reaches a stable state. There are four evolutionary stable strategies.

In case 1, the e-commerce platform will earn more if it restrains merchants from selling counterfeits, and the system may have an evolutionary stability point of (0,1,0) or (1,1,0). When these parameters satisfy condition 1, the eigenvalues of (0,1,0) are all negative value, so the ESS is (1,1,0). Similarly, when parameters satisfy conditions 2, the evolutionary stability point of the system is (1,1,0).

In case 2, the evolutionary stability point of the system may be (1,0,0) or (0,0,1) or (1,1,0). If parameters satisfy condition 3, the ESS is (1,0,0). When condition 4 is satisfied, (0,0,1) is the ESS. Both the government and e-commerce platform ignore sellers selling counterfeits, and it is not an optimal strategy. When condition 5 is satisfied, (1,1,0) is the evolutionary stable point, both government and e-commerce platforms strictly control.

4 Conclusion

From the perspective for regulation of merchants selling counterfeits, this paper constructs a game model with the government, e-commerce platform and consumer, and analyzes the stability of each player's strategy selection, and draws the following conclusions:

Government should establish reward and punishment mechanism. The government will incentivize those e-commerce platforms that find fraud, and impose heavy fines on those platforms that connive at fraud.

Cost also influence the strategic choice of government and e-commerce platforms. In order to reduce the cost of supervision, supervision information system should be established to realize real-time supervision.

In addition, high compensation and low feedback costs will encourage consumers to choose feedback as an evolutionary stable strategy. The punishment of merchant fraud should be increased and the protection of consumers should be strengthened.

Based on the research, this paper believes that the government and e-commerce platforms can effectively regulate the counterfeit selling behavior of merchants to a certain extent and promote the development of e-commerce platforms.

Reference

1. Y. Zhang. Discussion on E-commerce platform counterfeiting based on Game theory. Inform Syst Eng. **313**, 148-149 (2020).
2. F. YU. Research on Commodity Quality Control of C2C E-commerce Platform under the background of Big Data. Jilin Bus and Tech, **33**, 45-48 (2017).
3. W. HU. Discussion on Commodity Quality Control under Network Environment. Shopping Mall Mod, **876** (2018).
4. S. Sun, L. Zhu. Tripartite evolution simulation analysis of public participation in food quality supervision under new media environment. Mgt R, **33**, 315-326 (2021).
5. T. Yu, C. Liu. Evolution Game Analysis and Simulation Study between the Government and the Third Party in Product Quality Supervision. Chin Mgt sci, **6**, 7 (2016).
6. H. Zhang. E-commerce platform regulation and product quality game of agricultural product producers. Region Govern, **35**, 3 (2019).
7. S. Schmeiser. Consumer inference and the regulation of consumer information. IIO, **37**, 192-200 (2014).
8. F. Yang, A. Wang, J. Wu. Research on e-commerce credit supervision mechanism in C2B2C mode based on Game Theory. SETP, **37**, 9 (2017).
9. M. Xu, Q. Wang. An evolutionary game analysis of quality input in food supply chain. Chin Mgt sci, **05**, 131-122(2012).
10. J. Wang. Game study on the evolution of Agricultural product quality and Safety under the guidance of consumers. Food Ind, **08**, 231-235 (2015).
11. Z. SI. Balanced Analysis and Countermeasures of Brand Anti-counterfeiting Behavior Based on Game Theory. Ind I R, **9**, 6 (2018).
12. H. Guo, X. Zhao, J. Li. Game analysis of merchants and consumers confronting fakes on e-commerce platforms. Sys Sci& Ctrl Eng, **9**, 198-208 (2021).