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STUDY ON THE FAIRNESS CONCERNS STRATEGIES OF DUAL-CHANNEL IN MARKETING

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Abstract. *In order to increase market share and reduce sales risk, companies often use dual-channel model, which is a combination of direct (manufacturer-customer) and indirect (manufacturer-retailer-consumer) channel. The two channels have to balance fairness and benefit between them, and how to treat the others has become an important question. This paper focuses on the selection of fairness concerns strategy of dual-channel in marketing. We use evolutionary game model and system dynamics simulation to investigate it. The results show that in the dual-channel sales system, the direct channel will adopt fairness concerns behavior, and that the indirect channel will take the opposite behavior in the long term.*
Keywords: Sales channels, Fairness concerns, Evolutionary game, System dynamics

1. **Introduction.** In commercial activities, in order to increase market share and reduce sales risk, companies often use dual-channel model, which is a combination of direct (manufacturer-customer) and indirect (manufacturer-retailer-consumer) channel. According to the rationality assumption in traditional research, each channel will try to maximize its own benefit which will result in the "double marginalization" problem [1]. However, in reality, people often show great concern about fairness. People care not only about their own profit, but also the others. When they feel unequal, they tend to sacrifice their own interests to punish the others. That is fairness concerns [2].

In the dual-channel environment, profit distribution between manufacturers and retailers will trigger fairness concerns behavior [3]. Cui et al. [4] focused on how fairness concerns affected supply chain coordination. They found that when channel members are concerned about fairness, the manufacturer can use a simple wholesale price above her marginal cost to coordinate this channel both in terms of achieving the maximum channel profit and in terms of attaining the maximum channel utility. Ho et al. [5] focused on the simultaneously design problems when one of the distributors had both distributors and vertical fairness concerns in a system including one supplier and two distributors. Li and Li [6] considered the channel efficiency when the retailer has fairness concerns. They found that channel efficiency grows with increasing customer loyalty to the retail channel and falls with increases in the retailer's fairness concerns. Katok et al. [7] studied the performance of wholesale pricing when the supply chain partners' fairness concerns are private information. They found that some properties of wholesale pricing established under complete information hold under incomplete information as well.

The research achievements are worth to learn, but in practice, under the circumstance of limited rationality and different environment, how each channel chooses fairness concerns behavioral is still a problem to be investigated. Therefore, this paper established the evolutionary game model of direct and indirect sales channel based on fairness concerns.

We totally considered four situations of with/without fairness concerns combination for two sales channels, and get the optimal solution for each situation. Then we did simulation with system dynamics approach, and figured out the choice of fairness concerns for both parties in the dual-channel.

2. Model Notations and Modeling.

Two distribution channels are considered in this paper, the direct channel and indirect channel. For the unit price, direct channel is usually lower than indirect channel. The symbols defined in this paper are as follows.

A, B: income per unit of channels 1 and 2; Y, N: channel i have or do not have fairness concerns, $i \in \{1,\ 2\}$; E_{1ij}, E_{2ij}: the expected value of channels 1 and 2 when strategy i and j are chosen by channels 1 and 2 respectively, $i,\ j \in \{N,\ Y\}$; x, y: the probability of channels 1 and 2 chooses the behavior of fairness concerns; Q: the number of customers purchased the product; c_{1ij}, c_{2ij}: cost per unit of channels 1 and 2 when strategy i and j are chosen by channels 1 and 2 respectively, $i,\ j \in \{N,\ Y\}$; q_{1ij}, q_{2ij}: sales of channels 1 and 2 when strategy i and j are chosen by channels 1 and 2 respectively, $i,\ j \in \{N,\ Y\}$; α, β: customer's price sensitivity of channels 1 and 2.

2.1. Model without fairness concerns.

When neither channel 1 nor channel 2 cares about fairness concerns or has fairness preference, they do not care about how to distribute the profit in this channels. They only care about maximizing their own profit. In this case, according to [6],

$$\max_{p_{1NN}} E_{1NN} = (A - c_{1NN})(Q + \alpha c_{1NN} - \beta c_{2NN}) \tag{1}$$

$$\max_{p_{2NN}} E_{2NN} = (B - c_{2NN})(Q + \alpha c_{2NN} - \beta c_{1NN}) \tag{2}$$

Theorem 2.1. *Equations (1) and (2) are the concave functions of c_{1NN} and c_{2NN}.*

Proof: When taking first partial and second partial derivative to c_1 and c_2 based on Equations (1) and (2), we can get:

$$\frac{\partial E_{1NN}}{\partial p_{1NN}} = -Q - 2\alpha c_{1NN} + \alpha A + \beta c_{2NN},\ \frac{\partial^2 \pi_1}{\partial {p_1}^2} = -2\alpha$$
$$\frac{\partial E_{2NN}}{\partial p_{2NN}} = -Q - 2\alpha c_{2NN} + \beta c_{1NN} + \alpha B,\ \frac{\partial^2 \pi_{2NN}}{\partial {p_{2NN}}^2} = -2\alpha$$

Apparently,

$$\frac{\partial^2 E_{1NN}}{\partial {p_{1NN}}^2} = \frac{\partial^2 \pi_{2NN}}{\partial {p_{2NN}}^2} = -2\alpha < 0$$

So Theorem 2.1 is proved.

We can get the optimal result in this case:

$$E^*_{1NN} = \frac{\alpha[(2\alpha + \beta)Q + (2\alpha^2 - \beta^2)A - \alpha\beta B]^2}{(4\alpha^2 - \beta^2)^2}$$
$$E^*_{2NN} = \frac{\alpha[(2\alpha + \beta)Q + (2\alpha^2 - \beta^2)B - \alpha\beta A]^2}{(4\alpha^2 - \beta^2)^2}$$

2.2. Model with channel 1 possessing fairness concerns.

When channel 1 has fairness concerns, it not only cares about its own profit but also cares about the profit of retailer. However, retailer does not have fairness concerns and only cares about its own profit. In this case, according to [8], the fairness decision function is:

$$\max_{p_{1NY}} u_{1YN\lambda}(E) = E_{1NN} - \lambda(E_{2NN} - E_{1NN}) = (1 + \lambda)E_{1NN} - \lambda E_{2NN} \tag{3}$$

Similar to Theorem 2.1, when $\lambda > 0$, Equation (3) is concave function of c_{1YN}. So joining Equations (3) and (2), we can get the optimal result as below:

$$E_{1YN}^{**} = (A - c_{1YN}^{**})q_{1YN}^{**},\ E_{2YN}^{**} = (B - c_{2YN}^{**})q_{2YN}^{**}$$

2.3. **Model with channel 2 possessing fairness concerns.** When channel 2 has fairness concerns, it not only cares about its own profit but also cares about the profit of channel 1. However, channel 1 only cares about its own profit rather than the profit distribution fairness of whole channel. In this case, the fairness decision function is:

$$\max_{p_{2YN}} u_{NY\mu}(E) = E_{2NN} - \mu(E_{1NN} - E_{2NN}) = (1+\mu)E_{2NN} - \mu E_{1NN} \tag{4}$$

Joining Equations (1) and (4), we can get the optimal result as below:

$$E_{1NY}^{***} = (A - c_{1NY}^{***})q_{1NY}^{***},\ E_{2NY}^{***} = (B - c_{2NY}^{***})q_{2NY}^{***}$$

2.4. **Model with both members possessing fairness concerns.** When both channel 1 and channel 2 have fairness concerns, they care about the profit distribution of each other. In this case, the fairness decision function is:

$$\max_{p_{1YY}} u_{1\overline{\lambda}}(E) = E_{1NN} - \overline{\lambda}(E_{2NN} - E_{1NN}) = (1+\overline{\lambda})E_{1NN} - \overline{\lambda}E_{2NN} \tag{5}$$

$$\max_{p_{2YY}} u_{1\overline{\mu}}(E) = E_{2NN} - \overline{\mu}(E_{1NN} - E_{2NN}) = (1+\overline{\mu})E_{2NN} - \overline{\mu}E_{1NN} \tag{6}$$

Joining Equations (5) and (6), we can get the optimal result as below:

$$E_{1YY}^{****} = (A - c_{1YY}^{****})q_{1YY}^{****},\ E_{2YY}^{****} = (B - c_{2YY}^{****})q_{2YY}^{****}$$

3. **Evolutionary Game Model.**

3.1. **The evolutionary game model of fairness concerns in two channels.** Based on the optimal results from Sections 2.1-2.4, the expected value matrix of channel 1 and channel 2 are shown in Table 1.

TABLE 1. Expected value matrix of channel 1 and channel 2

Game member		Channel 2	
		Without fairness concerns	With fairness concerns
Channel 1	Without fairness concerns	E_{1NN}^{*}, E_{2NN}^{*}	E_{1NY}^{***}, E_{2NY}^{***}
	With fairness concerns	E_{1YN}^{**}, E_{2YN}^{**}	E_{1YY}^{****}, E_{2YY}^{****}

Whether the two channels will adopt fairness concerns have uncertainty and limited rationality. The strategy they adopt will have effect to the other channel of the supply chain. According to the natural selection thinking of evolutionary game theory, fitness determines the growth of strategy. The strategy with high-yield always has high growth rate as well. According to the above analysis from Sections 2.1-2.4 and Table 1, for channel 1, we can get the expected value without fairness concerns – E_{N1}, expected value with fairness concerns – E_{Y1}, and expected value with average strategy – E_{1X}.

$$E_{N1} = (1-y)E_{1NN}^{*} + yE_{1NY}^{***} \tag{7}$$

$$E_{Y1} = (1-y)E_{1YN}^{**} + yE_{1YY}^{****} \tag{8}$$

$$E_{1X} = (1-x)E_{N1} + xE_{Y1} \tag{9}$$

According to [10-12], we can get the replicator dynamics equation of channel 1 from Equations (7) to (9):

$$\frac{dx}{dt} = x(E_{Y1} - E_{1X}) = x^2[(1-y)(E_{1YN}^{**} - E_{1NN}^{*}) + y(E_{1YY}^{****} - E_{1NY}^{***})] \tag{10}$$

We can get the replicated dynamic equation of channel 2 in the same way:

$$\frac{dy}{dt} = y(E_{2Y} - E_{2NY}) = y^2[(1-x)(E_{2YN}^{**} - E_{2NN}^{*}) + x(E_{2YY}^{****} - E_{2NY}^{***})] \tag{11}$$

Equations (10) and (11) formed the dynamical system's replicated dynamic equation:

$$\begin{cases} \dfrac{dx}{dt} = x(E_{Y1} - E_{1X}) = x^2[(1-y)(E_{1YN}^{**} - E_{1NN}^{*}) + y(E_{1YY}^{****} - E_{1NY}^{***})] \\ \dfrac{dy}{dt} = \mathrm{y}(E_{2Y} - E_{2NY}) = y^2[(1-x)(E_{2YN}^{**} - E_{2NN}^{*}) + x(E_{2YY}^{****} - E_{2NY}^{***})] \end{cases} \tag{12}$$

3.2. **Evolutionary game model analysis of the two channels.**

(1) Evolutionary stability analysis for the channel 1 with fairness concerns.

Take $F(x) = \frac{dx}{dt}$, and take the derivation of the replicated dynamic Equation (10) for channel 1:

$$\frac{dF(x)}{dx} = 2x[(1-y)(E_{1YN}^{**} - E_{1NN}^{*}) + y(E_{1YY}^{****} - E_{1NY}^{***})]$$

Evolutionary stability analysis is as follows.

① When $y = \frac{E_{1NN}^{*} - E_{1YN}^{**}}{E_{1YY}^{****} + E_{1NN}^{*} - E_{1NY}^{***} - E_{1YN}^{**}}$, x is stable for any state.

② When $y \neq \frac{E_{1NN}^{*} - E_{1YN}^{**}}{E_{1YY}^{****} + E_{1NN}^{*} - E_{1NY}^{***} - E_{1YN}^{**}}$, take $F(x) = 0$, $x = 0$ is the stable state. According to the stability theorems of differential equations and the nature of evolutionary stability policy, $\left.\frac{dF(x)}{dx}\right|_{x=0} = 0$, so $x = 0$ is not the evolutionarily stable strategy (ESS).

(2) Evolutionary stability analysis for the channel 2 with fairness concerns.

In the same way, according to the replicated dynamic Equation (11), we can get:

$$\frac{dF(y)}{dy} = 2y[(1-x)(E_{2YN}^{**} - E_{2NN}^{*}) + x(E_{2YY}^{****} - E_{2NY}^{***})]$$

Evolutionary stability analysis is as follows.

① When $x = \frac{E_{2NN}^{*} - E_{2YN}^{**}}{E_{2YY}^{****} + E_{2NN}^{*} - E_{2NY}^{***} - E_{2YN}^{**}}$, y is stable for any state.

② When $x \neq \frac{\pi_{2NN}^{*} - \pi_{2YN}^{**}}{\pi_{2YY}^{****} + \pi_{2NN}^{*} - \pi_{2NY}^{***} - \pi_{2YN}^{**}}$, take $F(y) = 0$, $y = 0$ is the stable state. Then according to the stability theorems of differential equations and the nature of evolutionary stability policy $\left.\frac{dF(y)}{dy}\right|_{y=0} = 0$, so $y = 0$ is not the ESS.

(3) The evolutionary stability analysis of channels 1 and 2's strategy.

When $0 \leq x^* = \frac{E_{2NN}^{*} - E_{2YN}^{**}}{E_{2YY}^{****} + E_{2NN}^{*} - E_{2NY}^{***} - E_{2YN}^{**}}$, $y^* = \frac{E_{1NN}^{*} - E_{1YN}^{**}}{E_{1YY}^{****} + E_{1NN}^{*} - E_{1NY}^{***} - E_{1YN}^{**}} \leq 1$: the single evolutionary stability analysis of two channels shows that the replicated dynamic equilibrium points of two sales channels are (0, 0), (x^*, y^*). For a group dynamics described by a system of differential equations, the stability of the equilibrium point can be made of local stability analysis of Jacobian Matrix, that is:

$$J=\begin{bmatrix} \frac{\partial F(x)}{\partial X} & \frac{\partial F(x)}{\partial Y} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} \end{bmatrix}$$
$$=\begin{bmatrix} 2x[(1-y)(E_{1YN}^{**}-E_{1NN}^{*})+y(E_{1YY}^{****}-E_{1NY}^{***})] & x^2(E_{1YY}^{****}+E_{1NN}^{*}-E_{1YN}^{**}-E_{1NY}^{***}) \\ y^2(E_{2YY}^{****}+E_{2NN}^{*}-E_{2YN}^{**}-E_{2NY}^{***}) & 2y[(1-x)(E_{2YN}^{**}-E_{2NN}^{*})+x(E_{2YY}^{****}-E_{2NY}^{***})] \end{bmatrix}$$

According to Friedman [10], when the stability of the equilibrium point is any of the local stable point of the evolutionary dynamic process, the equilibrium point is an ESS, and at the same time, to sufficient condition of $\det(J) > 0$ and $tr(J) < 0$, it is the stable point. However, the steady state is not all the evolutionarily stable strategy, and it must require a stable state with anti-disturbance function, that is $\partial F(X)/\partial X < 0$, $\partial F(Y)/\partial Y < 0$ [10]. For the point $(0,0)$, because of $\det(J)|_{(0,0)} = 0$, $\det(J)|_{(0,0)} = 0 : (0,0)$ is not the equilibrium point; for (x^*, y^*), because of $\det(J)|_{(x^*,y^*)} < 0$, $tr(J)|_{(x^*,y^*)} = 0 : (x^*, y^*)$ is not the equilibrium point.

4. **System Dynamics Simulation.** In this section, we present the result by the system dynamics simulation. In order to demonstrate clearly on the decision making of the two channels on whether to adopt fairness concerns behavior, we simulate the change of expected value over time under the different condition by the system dynamics approach. Compared to channel 2, channel 1 eliminates the profit shared to distributors. So the profit of channel 1 is higher than channel 2. Suppose the income of channel 1 is 7000 RMB, for channel 2 is 4000 RMB; customer's price sensitivity of channel 1 is $\alpha = 0.3$, for channel 2 is $\beta = 0.2$. When adopting fairness concerns $\lambda = 0$, $\mu = 0$; while not, λ, μ are uniform distribution in $[0, 1]$.

The simulation result is shown as follows, the x-axis means the time (week as a unit) and y-axis means the expected value. Figure 1 and Figure 2 show that when channel 1 adopts fairness concerns while channel 2 does not, the expected value of channel 1 increases over time, but channel 2 gets the opposite result. Therefore, in this case, adopting fairness concerns is more favorable for channel 1 and less favorable for channel 2.

Figure 3 and Figure 4 show that when channel 1 does not adopt fairness concerns while channel 2 does, both expected values of channel 1 and 2 decrease over time. So when channel 1 does not adopt fairness concerns, to adopt fairness concerns is not good for channel 2; and similar equally when channel 2 adopts fairness concerns, to drop fairness concerns is not good for channel 1.

Figure 5 and Figure 6 show that when both channels adopt fairness concerns, the expected value of channel 1 will decline first and then ascend, so this case is favorable for channel 1. However, the expected value of channel 2 decreases over time, so both channels adopting fairness concerns will do harm to channel 2.

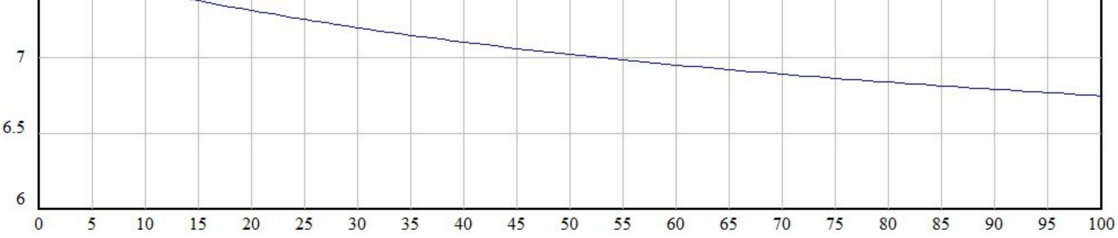

FIGURE 1. The tendency of E_{1YN}

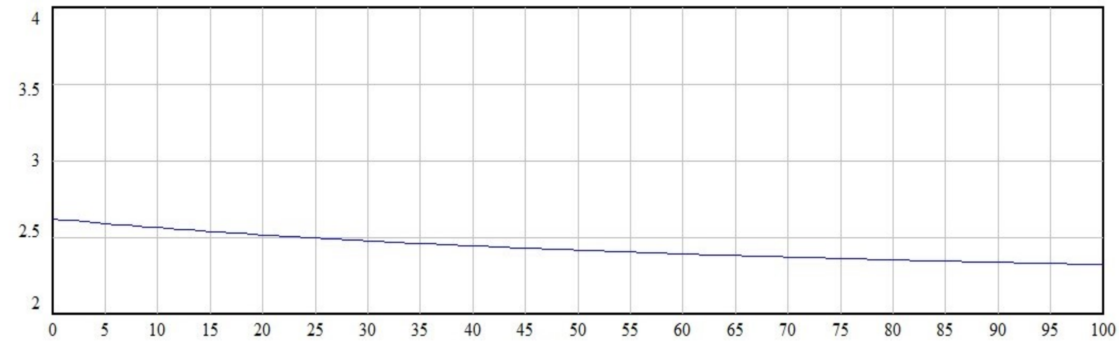

FIGURE 2. The tendency of E_{2YN}

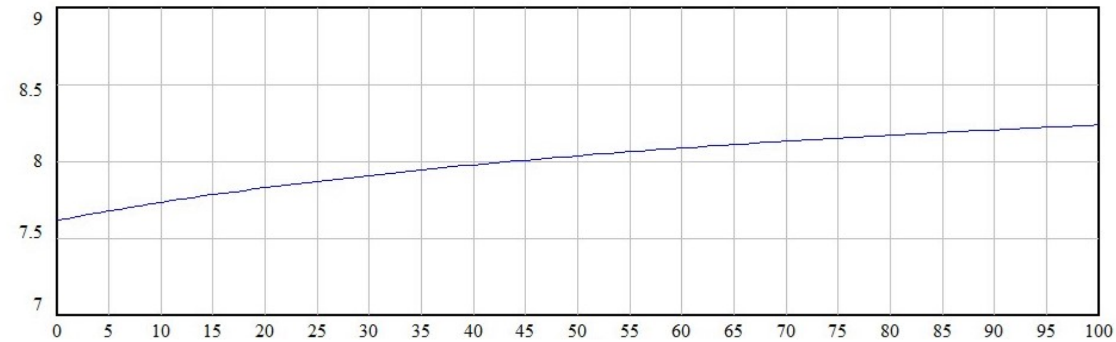

FIGURE 3. The tendency of E_{1NY}

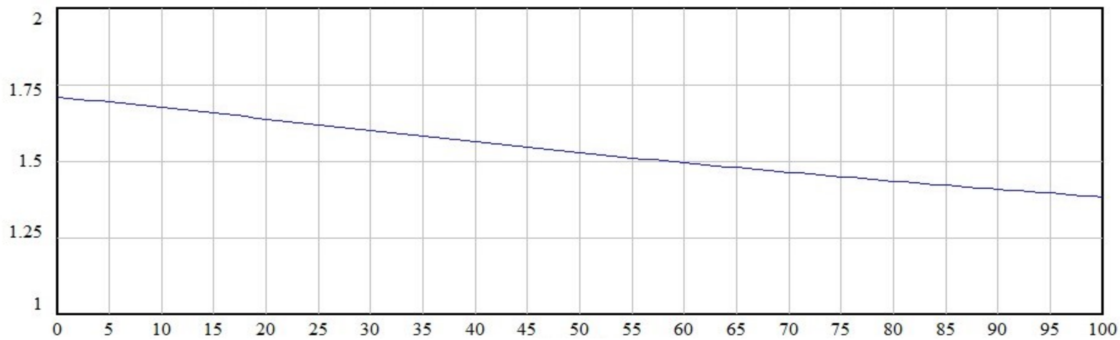

FIGURE 4. The tendency of E_{2NY}

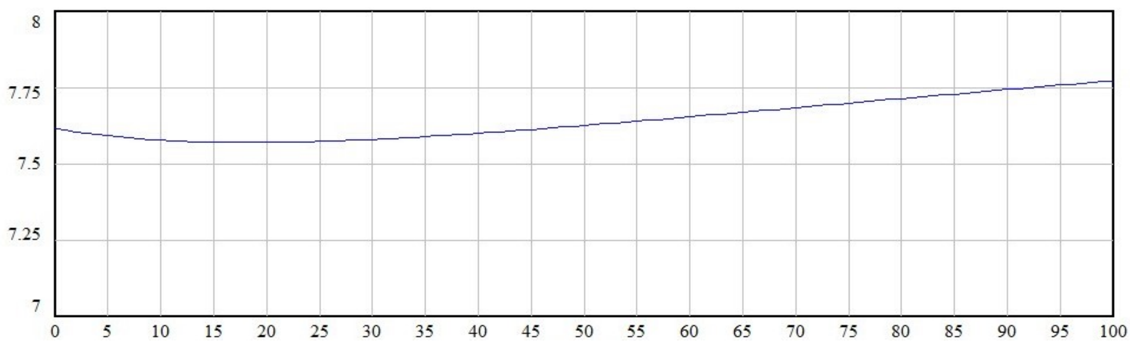

FIGURE 5. The tendency of E_{1YY}

Based on the above analysis, when channel 1 adopts fairness concerns, the expected value will increase over time; regardless of channel 2 adopting fairness concerns not, its expected value will decline over time. Which strategy is going to choose is decided by the

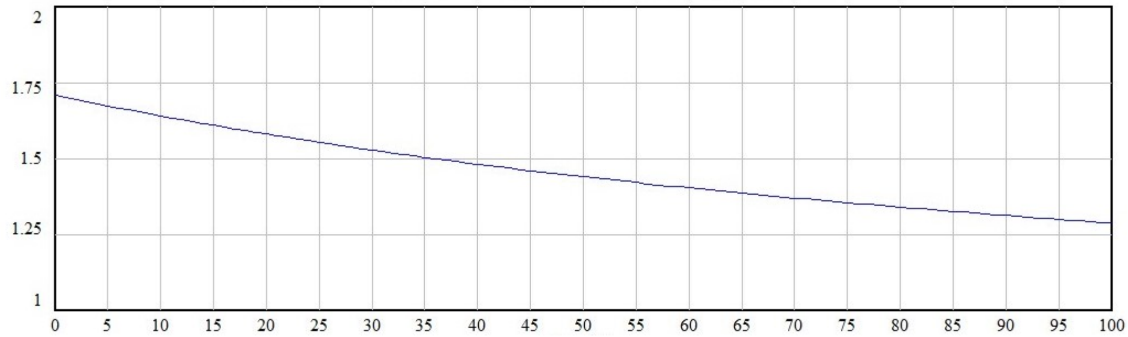

Figure 6. The tendency of E_{2YY}

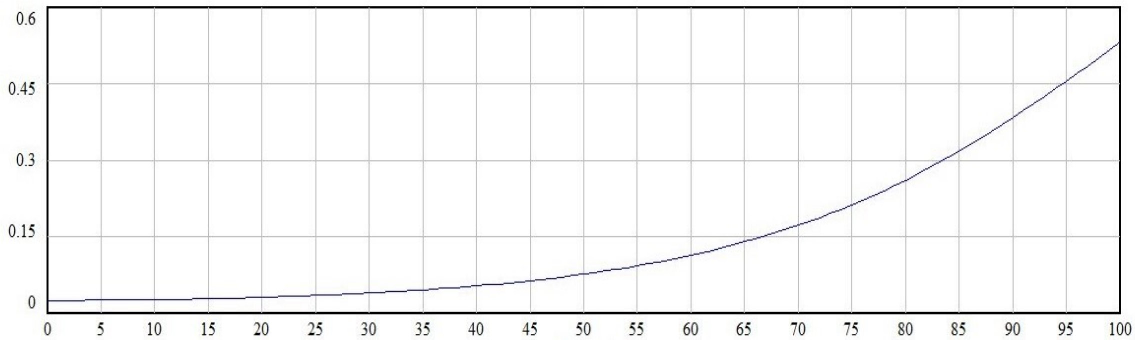

Figure 7. The tendency of X

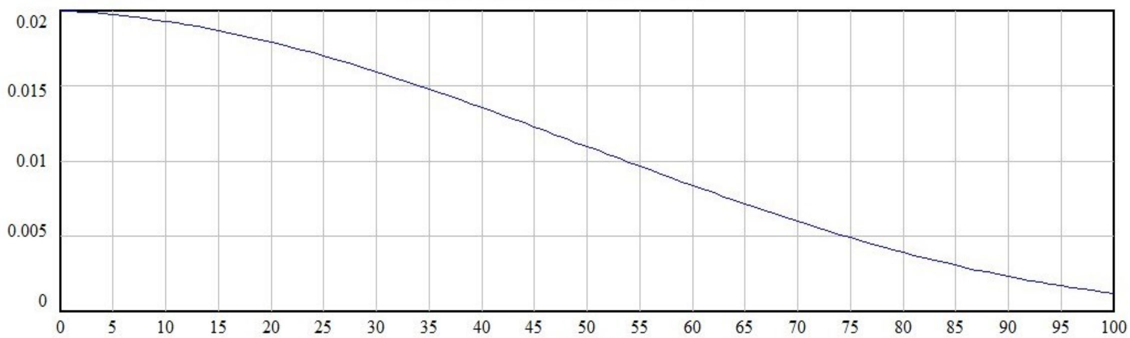

Figure 8. The tendency of Y

expected value. In the result of Figure 7 and Figure 8, the x-axis means the time (week as a unit) and y-axis means the possibility. Figure 7 and Figure 8 show that in the long run, channel 1 will adopt fairness concerns while channel 2 does not.

5. **Conclusions and Prospect.** In this paper, we analyze whether direct and indirect sales channel will adopt fairness concerns behavior by using evolutionary game approach. Based on it, we perform numerical analysis using system dynamics method. Evolutionary game results and numerical analysis show that, in dual-channel marketing system, direct sales channels will pay attention to the whole sales channels; while indirect channels only concern about itself and will not adopt fairness concerns. In business, direct sales channels should take actions to avoid adverse effects to the whole sales system by concerning the indirect channels.

There are several limitations in this paper that deserve further research. Firstly, the object of research is simple. This paper studies a simple dual-channel combination with one manufacturer and one retailor without considering the competition and cooperation between the two channels. Secondly, practical implication is not enough. This paper only studies the tendency of fairness concerns in a dual-channel market, and does not discuss how to correct and guide such behavior. Therefore, future research should consider the competition and cooperation of several companies in each channel, and study more elements of behavioral tendencies to better guide practice.

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