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摘要

本研究設立一個雙元通路的最適租稅模型，以探討電子商務的銷售稅課徵。模型是由政府、廠商與消費者的決策共同構成一個四階段的賽局，其中廠商銷售通路決策的內生化是最大特色。本研究發現，無論市場是獨占或寡占，雙元通路均非社會最適。然而，如果存在雙元通路，基於消費的網路外部性，電子商務應享有優惠的租稅待遇。

關鍵詞: 電子商務、網路外部性、最適租稅、銷售稅

Abstract

This paper provides a theoretical dual-channel model of optimal taxation to analyze the tax treatment on electronic commerce. The model characterized by the endogeneity of decisions about selling channel is a four-stage game. The results suggest first that dual-channel structure is not socially optimal in a monopoly or duopoly. However, if it historically happened, then the preferential tax on electronic commerce would be desirable as long as consumption externalities exist.

Keywords: electronic commerce; network externality; optimal taxation; sales tax

1. Introduction

Despite the heated debates over taxation of electronic commerce, most of the existing literature has focused on legal or administrative issues. The few conceptual discussions are lack of systematic analyses in a framework of optimal taxation. One exception is Bruce et al. (2003), who examine the question of whether or not to tax electronic commerce based on considerations of efficiency, equity, administration and compliance, and revenue. They conclude that generally the optimal tax literature cannot be used in support of a blanket tax exemption for Internet purchases.

It is admitted that the optimal tax theory does not consider the differential taxation problem in the context of trading forms. Bruce et al. (2003) treat the goods bought via two different channels as two separate goods, based on the difference of transaction cost. However, while the substitution between electronic and tradition purchasing channels for buyers has been considered in their paper, the possibility for producers facing a specific tax structure to switch the selling channels has never been addressed.

In this paper we propose a theoretical foundation of optimal taxation to analyze the tax treatment on electronic commerce. We consider the existence of two selling channels consisting of an electronic channel and a traditional channel. Of course, the heart of our analyses is the endogenous decision of selling channel. The optimal taxation on electronic commerce is investigated respectively under two market structures: monopoly and duopoly. Electronic commerce brings consumers network externalities. In the model of duopoly, consumers are assumed to be heterogeneous in the preference for brands of which the products might be sold in different channels. The model also considers some distinguishing factors of electronic commerce, like consumers' virtual acceptance and lower transaction cost.

2. The model

2.1 Monopoly market structure

Consider a manufacturer who sells a product to a market of $2n$ identical consumers. The manufacturer may distribute the product to either or both of shopping channels. Assume that each consumer derives utility from the consumption of the commodity and buys at most one unit. Let v be the basic utility gained from consuming the product that is bought through an offline store. When the product is bought online through virtual inspection, it is assumed to have smaller value αv, where $0 \leq \alpha \leq 1$. It is also assumed that the consumption through online trade exhibits network externalities. Moreover, the consumption externalities increase with the numbers of consumers. Let p and q denote the price and the number of buyers respectively. A commodity tax is levied on the good, and the taxation is ad valorem with tax rate t. The consumer surplus of each consumer is given by $s_e = \alpha v - (1+t_e)p_e + \theta q_e$, if good is bought through electronic channel, and $s_r = v - (1+t_r)p_r$, if good is bought through traditional channel, where the subscripts e and r represent electronic and traditional channels respectively, and θ stands for consumers' preference for consumption externalities.

The monopolist has two decisions in a sequential manner. Firstly, the manufacturer decides selling channel, and then he chooses a price which maximizes his profits. For simplicity, assume that there is no fixed cost of production. Let c_e and c_r be marginal costs incurred by the manufacturer for the product sold through the electronic and traditional channels. Normally, it is expected that $c_e < c_r$.

The decisions of all agents in the model can be divided into four stages. In the first stage, the government sets the commodity tax rates to maximize social welfare. In the second and third stages, selling channel and pricing are decided by the manufacturer. In the fourth stage, consumers make their purchasing decisions. In the following, we solve this game backward.

Let us first consider consumers' purchasing decisions. If each consumer obtains more surplus from the purchase through electronic channel, then the total demands faced by the monopolist are $q_e = 2n$ and $q_r = 0$. Subject to consumers' demand function, the monopoly's profit maximizing price and his associated profit are

$$p_e = \frac{\alpha v + 2n\theta}{1+t_e}, \tag{1}$$

$$\pi_e = 2n(\frac{\alpha v + 2n\theta}{1+t_e} - c_e). \tag{2}$$

If $s_r > s_e$, then $q_r = 2n$ and $q_e = 0$. The monopoly's maximizing profit price and the corresponding profit are as follows:

$$p_r = \frac{v}{1+t_r}, \tag{3}$$
$$\pi_r = 2n(\frac{v}{1+t_r} - c_r). \tag{4}$$

If $s_e = s_r$, then the monopolist could sell the commodity through dual channels and the prices p_e and p_r are determined as follows:

$$\begin{array}{ll} max & \pi = (p_e - c_e)q_e + (p_r - c_r)(2n - q_e) \\ s.t. & \alpha v - (1+t_e)p_e + \theta q_e = v - (1+t_r)p_r. \end{array} \tag{5}$$

It can be shown that selling through a single channel rather than dual channels is the best choice for the monopolist.

Let's turn to the monopolist's marketing decision. In this stage, the monopolist decides which channel to sell the product. The result is that the monopolist will sell the product through electronic channel if and only if

$$c_r - c_e > \frac{(1+t_e)v - (1+t_r)(\alpha v + 2n\theta)}{(1+t_e)(1+t_r)}. \tag{6}$$

Before proceeding to optimal tax policy, we answer an important question at this point, that is whether the monopolist's decisions of marketing and pricing are socially optimal. Define social welfare as the sum of consumers' surplus, the monopolist's profit and tax revenues. Thus, social welfares under the two situations of single selling channel are given by

$$W_e = 2n(\alpha v + 2n\theta - c_e), \tag{7}$$
$$W_r = 2n(v - c_r). \tag{8}$$

Suppose that there are dual selling channels, then social welfare is

$$W = (\alpha v + \theta q_e - c_e)q_e + (v - c_r)(2n - q_e). \tag{9}$$

It is easily shown that from the viewpoint of social welfare, the optimal q_e is equal to $2n$. With regard to the two selling channels, the comparisons of social welfare indicate that electronic commerce is more desirable than traditional trading if and only if $c_r - c_e > (1-\alpha)v - 2n\theta$.

The desirability of selling channel selected by the monopolist and the associated welfare under each tax regime are summarized in the following proposition:

Proposition 1. *(i) Under the regime of no commodity tax, the selling channel selected by the monopolist is optimal. And the social welfare in equilibrium is maximal. (ii) Under the regime of neutral taxation, the selling channel is optimal if and only if* $c_r - c_e > (1-\alpha)v - 2n\theta$ *or* $c_r - c_e < ((1-\alpha)v - 2n\theta)/(1+t)$. *Once the selling channel is optimal, the social welfare in equilibrium is maximal. (iii) Under the regime of tax exemption of electronic commerce, the selling channel is optimal if and only if* $c_r - c_e > (1-\alpha)v - 2n\theta$ *or* $c_r - c_e < v/(1+t_r) - (\alpha v + 2n\theta)$. *Once the selling channel is optimal, the social welfare in equilibrium is maximal.*

2.2 Duopoly with heterogeneous consumers

Consider a duopoly industry producing two brands A and B. Consumers have different preference toward the two brands. Suppose that $2n$ potential consumers distribute uniformly between $[0, 1]$ according to their preference toward brands. A consumer's location in the preference spectrum is indexed by $z \in [0, 1]$, that is the distance from brand A. If she buys brand A, then she has disutility of δz, where δ can be thought of as the disutility per unit of deviation of buying brand from what she prefers most. On the contrary, her disutility of buying brand B is $\delta(1-z)$. Thus, the total cost of purchase is composed of after-tax price of the product and disutility of buying a specific brand.

Case 1: $s_e^A > s_r^A$ and $s_e^B > s_r^B$

In this case, all consumers want to purchase the commodity through electronic channel. The location of the consumer who is indifferent between the two brands is the point z_e such that

$$z_e = \frac{\delta + (1+t_e)(p_e^A - p_e^B)}{2\delta}, \tag{10}$$

where the superscripts A and B of variables denote the respective brand.

Firm A's demand equals $2nz_e$ when $z_e \in [0, 1]$, $2n$ when $z_e > 1$, and 0 when $z_e < 0$. Thus we have

$$q_e^A = \begin{cases} 0 & \text{if } (1+t_e)p_e^A > (1+t_e)p_e^B + \delta \\ \frac{n}{\delta}(\delta + (1+t_e)(p_e^B - p_e^A)) & \text{if } (1+t_e)p_e^A \in [(1+t_e)p_e^B - \delta, (1+t_e)p_e^B + \delta] \\ 2n & \text{if } (1+t_e)p_e^A < (1+t_e)p_e^B - \delta \end{cases}$$

By the symmetry, the demand function of firm B could also be derived. Solving the maximization problem of firm i, $i = A, B$, we obtain his response function $b(p_e^{-i})$. In any Nash equilibrium, $b(p_e^{-i}) = p_e^i$, $i = A, B$. Thus, the equilibrium prices are

$$p_e^i = \frac{1}{3}(\frac{3\delta}{1+t_e} + 2c_e^i + c_e^{-i}), \quad i = A, B. \tag{11}$$

Substituting the equilibrium prices into the equations of $q_e^i, i = A, B$, we have

$$q_e^i = n(1 + \frac{(1+t_e)(c_e^{-i} - c_e^i)}{3\delta}), \quad i = A, B. \tag{12}$$

The profit of firm i is

$$\pi_e^i = \frac{n}{9\delta(1+t_e)}(3\delta + (1+t_e)(c_e^{-i} - c_e^i))^2. \tag{13}$$

In this case, the consumer who is indifferent between brand A and B has a preference for brands defined by

$$z_e = \frac{\delta + (1+t_e)(c_e^B - c_e^A)}{2\delta}. \tag{14}$$

The aggregate surpluses for both types of consumers are therefore given by $2n\int_0^{z_e} s_e^A dz$ and $2n\int_{z_e}^1 s_e^B dz$. The tax revenue from electronic commerce is $2nt_e(p_e^A z_e + p_e^B(1-z_e))$. In aggregate, the social welfare is

$$W_e = 2n[(\alpha v + 2n\theta - \frac{\delta}{2}) - c_e^A z_e - c_e^B(1-z_e) + \delta z_e(1-z_e)]. \tag{15}$$

Case 2: $s_r^A > s_e^A$ and $s_r^B > s_e^B$

Each consumer, irrespective of her preference for commodity brand, want to purchase offline in this case. The consumer who is indifferent to buy brand A or B is characterized by

$$z_r = \frac{1}{2}[\delta + (1+t_r)(p_r^B - p_r^A)]. \tag{16}$$

Given a pair of prices (p_r^A, p_r^B), the market demand for each brand can be derived. The Bertrand equilibrium of the four-stage game is further solved, which are characterized by equilibrium prices, quantities and profits as equations (11)-(13) show, except that the tax rate t_e, and the marginal costs of the two firms c_e^A and c_e^B, are replaced by t_r, c_r^A, and c_r^B respectively. The consumers surpluses from buying brand A and B can be further derived, based on $2n\int_0^{z_r} s_r^A dz$ and $2n\int_{z_r}^1 s_r^B dz$. And the social welfare is given by

$$W_r = 2n[(v - \frac{\delta}{4}) - \frac{1}{2}(c_r^A + c_r^B) + \frac{(1+t_r)(5-t_r)}{36\delta}(c_r^B - c_r^A)^2]. \tag{17}$$

Case 3: $s_e^A > s_r^A$ and $s_r^B > s_e^B$

In this case, the marginal consumer is located at z_d, where

$$z_d = \frac{1}{2(\delta - n\theta)}((\alpha-1)v + \delta + (1+t_r)p_r^B - (1+t_e)p_e^A). \tag{18}$$

All the consumers with brand preference in the interval $[0, z_d]$ buy brand A online, otherwise they buy brand B offline. Demands for brand A and B are thus

$$q_e^A = \begin{cases} 0 & \text{if } P_e^A > P_r^B + \delta + (\alpha-1)v \\ \frac{n}{\delta - n\theta}(\delta + (\alpha-1)v + (P_r^B - P_e^A)) & \text{if } P_e^A \in [P_r^B - \delta + (\alpha-1)v + 2n\theta, \\ & P_r^B + \delta + (\alpha-1)v] \\ 2n & \text{if } P_e^A < P_r^B - \delta + (\alpha-1)v + 2n\theta \end{cases}$$

$$q_r^B = \begin{cases} 0 & \text{if } P_r^B > P_e^A + \delta + (1-\alpha)v - 2n\theta \\ \frac{n}{\delta - n\theta}(\delta + (1-\alpha)v - 2n\theta - (P_r^B - P_e^A)) & \text{if } P_r^B \in [P_e^A - \delta + (1-\alpha)v, \\ & P_e^A + \delta + (1-\alpha)v - 2n\theta] \\ 2n & \text{if } P_r^B < P_e^A - \delta + (1-\alpha)v \end{cases}$$

where P_e^A and P_r^B are after-tax prices of the two brands.

The Bertrand equilibrium before-tax prices are given respectively by

$$p_e^A = \frac{1}{3(1+t_e)}((\alpha-1)v + 3\delta - 2n\theta + 2(1+t_e)c_e^A + (1+t_r)c_r^B), \tag{19}$$

$$p_r^B = \frac{1}{3(1+t_r)}((1-\alpha)v + 3\delta - 4n\theta + 2(1+t_r)c_r^B + (1+t_e)c_e^A). \tag{20}$$

It follows that the optimal outputs are, respectively,

$$q_e^A = \frac{1}{3(\delta - n\theta)}((\alpha-1)v + 3\delta - 2n\theta - (1+t_e)c_e^A + (1+t_r)c_r^B), \tag{21}$$

$$q_r^B = \frac{1}{3(\delta - n\theta)}((1-\alpha)v + 3\delta - 4n\theta - (1+t_r)c_r^B + (1+t_e)c_e^A). \tag{22}$$

The corresponding profits are

$$\pi_e^A = \frac{n((\alpha-1)v+3\delta-2n\theta-(1+t_e)c_e^A+(1+t_r)c_r^B)^2}{9(\delta-n\theta)(1+t_e)}, \quad (23)$$

$$\pi_r^B = \frac{n((1-\alpha)v+3\delta-4n\theta-(1+t_r)c_r^B+(1+t_e)c_e^A)^2}{9(\delta-n\theta)(1+t_r)}. \quad (24)$$

The social welfare is given by

$$W_d = 2n[v-\frac{\delta}{2}-c_r^B+((\alpha-1)v-c_e^A+c_r^B+\delta)z_d+(2n\theta-\delta)z_d^2], \quad (25)$$

where

$$z_d = \frac{(\alpha-1)v+3\delta-2n\theta-(1+t_e)c_e^A+(1+t_r)c_r^B)}{6(\delta-n\theta)}.$$

Next turn to the decision of selling channels. Since the results are too complicated to give explicit self-selection conditions, we focus on the special case in which there is no commodity tax and costs are identical for both firms regardless of selling channels. According to the self-selection constraints for both firms, we show that with no tax and no cost difference, both firms will never sell product through different channels.

Proposition 2. *Suppose that* $t_i = 0$, *and* $c_i^A = c_i^B = c_i, \quad i = e, r$. *Then*
(a)in the duopoly market with Bertrand competition, only single selling channel, either electronic or traditional, exists;
(b)when both firms sell through the same channel, $\pi_e^A = \pi_e^B = \pi_r^A = \pi_r^B = n\delta$.

From the viewpoint of social planner, which kind of channel structure is desirable? In the first two cases of single channel, the optimal segmentation of consumers and the associated social welfare are derived as follows:

$$z_e^* = \frac{1}{2\delta}(\delta+c_e^B-c_e^A), \quad (26)$$

$$W_e^* = \frac{n}{2\delta}[(c_e^B-c_e^A)^2-2\delta(c_e^A+c_e^B)+\delta(-\delta+4\alpha v+8n\theta)], \quad (27)$$

$$z_r^* = \frac{1}{2\delta}(\delta+c_r^B-c_r^A), \quad (28)$$

$$W_r^* = \frac{n}{2\delta}[(c_r^B-c_r^A)^2-2\delta(c_r^A+c_r^B)+\delta(-\delta+4v)]. \quad (29)$$

Suppose that both firms are equally efficient. Comparing equation (29) with (27) yields that electronic selling is socially preferred if $c_r - c_e > (1-\alpha)v - 2n\theta (\equiv u)$; otherwise, traditional selling is optimal.

In the dual-channel case, the optimal division of market and the associated social welfare are obtained as follows:

$$z_d^* = \frac{1}{2(\delta - 2n\theta)}(\delta + (\alpha - 1)v + c_r^B - c_e^A), \quad (30)$$

$$W_d^* = \frac{n}{2}[4(v - c_r^B) - 2\delta + \frac{(c_r^B - c_e^A)^2 + (\alpha - 1)v + \delta)^2}{\delta - 2n\theta}]. \quad (31)$$

Comparing equation (31) with (29) and (31) with (27) yields

$$W_d^* > W_e^* \text{ if and only if } c_r - c_e < (1-\alpha)v + \delta - 4n\theta - (2\delta(\delta - 2n\theta))^{1/2} \equiv u_1,$$

$$W_d^* > W_r^* \text{ if and only if } c_r - c_e > (1-\alpha)v - \delta + (\delta(\delta - 2n\theta))^{1/2} \equiv u_2.$$

Since $u_1 < u < u_2$, there are four kinds of relations among W_e^*, W_r^*, and W_d^*: $(i) c_r - c_e > u_2 : W_e^* > W_d^* > W_r^*$; $(ii) u < c_r - c_e \leq u_2 : W_e^* > W_r^* > W_d^*$; $(iii) u_1 < c_r - c_e \leq u : W_r^* > W_e^* > W_d^*$; $(iv) c_r - c_e \leq u_1 : W_r^* > W_d^* > W_e^*$. The comparison results reveal that it is also undesirable for the whole society to trade in a dual-channel, symmetric duopoly market with no tax.

Proposition 3. *Suppose that $t_i = 0$, and $c_i^A = c_i^B = c_i, \quad i = e, r$. Then*

(a)single channel is always preferred to dual channels;

(b)the single electronic channel is preferred to the single traditional channel if and only if $c_r - c_e > (1-\alpha)v - 2n\theta$.

It is apparent that in a symmetric duopoly market with no tax distortion, the choice of selling channel made by both firms noncooperatively coincide with the social optimal one.

3. Optimal tax policy

3.1 Taxation under monopoly

Assume that the tax revenue required is T^*. First, consider the situation under which the monopolist sells product in electronic channel. The government maximizes the sum of $(\pi_e + s_e)$, subject to the constraint $T \geq T^*$. The optimal tax in an electronic market is

$$t_e^* = \frac{T^*}{2n(\alpha v + 2n\theta) - T^*}. \tag{32}$$

Similarly, for the traditional trade, the optimal tax rate is given by

$$t_r^* = \frac{T^*}{2nv - T^*}. \tag{33}$$

Proposition 4. *In a monopoly market, to raise the same amount of tax revenue, the tax rate under the regime of single channel is lower for electronic commerce than for traditional trade if and only if the product value from consumption is higher in the former case. The optimal tax on electronic commerce is negatively correlated with the value of consumption externalities for consumers.*

3.2 Taxation under duopoly

For simplicity, the analysis in the following will confine to the case where all tax revenues are returned to consumers as a lump-sum. It shows that the optimal commodity tax under single channel is exactly equal to 2, no matter what channel the product is sold through. In a single channel with the optimal tax, Bertrand competition leads to maximum of social welfare.

Proposition 5. *In a duopoly market, the optimal tax rate under each single regime is constant and equal 2, if the tax revenue is rebated as a lump-sum.*

Under a dual-channel regime, it is surprising that the two tax rates should keep a positive linear relationship in order to attain the maximum of welfare. That is $t_e = [(c_e^A - c_r^B + (1-\alpha)v)(2\delta - n\theta) + n\theta(4n\theta - 5\delta) + c_r^B(\delta - 2n\theta)t_r]/c_e^A(\delta - 2n\theta)$.

To capture the whole picture, we adopt the method of numerical simulation. First, the parameters and variables of demand and supply are set as follows: $n = 100$, $v = 1$, $\alpha = 0.9$, $\delta = 0.1$, $c_e^A = 0.15$, and $c_r^B = 0.25$. Since the preference for consumption externalities has negative influence on the optimal t_e, other things being equal, we simulate two cases with different values of θ. In the first case, where θ is set to be 0.0001, if t_r is in $(0, 0.23)$, then the optimal value of t_e is negative. The first column of Table 1 shows one of the simulated results in which the two types of trading have differentiated tax treatment, and the net revenue for government is positive.

In the second case, the preference parameter θ is equal 0.00012. From equation of t_e, we learn that if t_r is set in (0, 0.285), then t_e should be set to be negative. Selecting a pair of optimal tax (subsidy) rates $(t_e, t_r) = (-0.06, 0.25)$ such that the net tax revenue is equal to the amount in the first case, the equilibria of this four-stage game are simulated and presented in the second column of Table 1.

In these two cases, traditional trades are taxed, while electronic trades are subsidized. The net and the gross prices in traditional channel are higher than those in electronic channel. The market share of brand A is more than 60%. Firm A who sells product through electronic channel earns more profit than firm B who is in traditional channel. On average, the consumer surplus per capita in electronic channel is slightly higher than that in traditional channel. Finally, as consumers' preference for consumption externalities gets stronger, to obtain the same amount of net tax revenue, the unit subsidy on electronic commerce and the unit tax on traditional trade both should be raised up. The overall social welfare improves to some extent.

4. Conclusion

In this paper, we provide a framework to examine optimal taxation on electronic commerce to remedy inadequacy of existing conceptual discussions. Especially, we take explicitly producer's decision on dual channels, a virtual channel and a real channel, into account.

We show that single channel is socially preferred to dual channels in either a monopoly or a duopoly market. However, with tax enforcement, producer's choice of selling channel generally is inappropriate. Regarding the tax treatment, we find that in a monopoly market, electronic commerce should be given preferential tax under single regime. In a duopoly market with Bertrand competition and single channel, the optimal tax is neutral. Finally, under dual-channel regime in a symmetric duopoly, electronic commerce should be subsidized, while traditional trade is taxed.

This study is a solid step toward assessing tax policy on electronic commerce in a systematic approach. A number of extensions might be considered however. For example, consumption risks and the enforcement costs may have important role in sales tax policy.

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TABLE 1
Simulation results of optimal taxation, market equilibria and welfare: dual-channel duopoly

	case 1: $\theta = 0.0001$		case 2: $\theta = 0.00012$		no externality	
	electronic	traditional	electronic	traditional	electronic	traditional
t	-0.05	0.20	-0.06	0.25	0.065	0.039
p	0.268	0.306	0.273	0.298	0.244	0.260
P	0.255	0.368	0.257	0.373	0.346	0.360
q	125	75	132	68	100	100
S	78.281	46.031	82.389	41.762	61.532	61.532
π	14.803	4.219	16.214	3.298	9.394	9.627
T	2.916		2.916		2.916	
W_d	146.250		146.579		145	
z_d	0.623		0.658		0.5	