Agricultural Products’ Custom Bundling Pricing Based on Positive Externality

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Abstract. Agriculture, rural and farmers are world-wide issues, and agricultural products have long been a problem for China’s “agriculture, rural and farmers”. Because agricultural products show strong positive externality, the formulation of bundled pricing strategy can not only reflect the characteristics of agricultural products, but also in line with the development trend of Chinese agriculture. This paper studies the pricing of product bundles under positive externality- with agricultural products as the object, combined with the pricing of agricultural products, and discusses the situation of custom bundled pricing of agricultural products under positive externality, and provides reference to the custom bundled pricing strategies of agricultural products for rural areas, agriculture and farmers in China.

1. Introduction

Externality is a conceptual category in the field of economics, which is usually divided into positive externalities and negative externalities. The positive externalities are divided into direct positive externalities and indirect positive externalities. Direct positive externality generally refers to the increase of consumer utility with the increase of the total number of consumers of similar products, that is, the positive relationship between value and scale. Indirect positive externalities mean sourcing the value of a product as the variety of complementary products increases [1-6]. Agricultural products are more typical positive externality products, and their consumption has a strong positive externality. This positive externality involves both direct and positive externalities. The formulation of bundled pricing strategy can not only reflect the characteristics of agricultural products, but also conform to the development trend of Chinese agriculture, so it is necessary to study the custom bundled pricing strategy of agricultural products under positive externality. Therefore, this paper discusses the positive externality pricing strategy of Chinese agricultural products. Taking agricultural products as the object, combined with the problem of agricultural product pricing, discusses the situation of custom bundled pricing of agricultural products under positive externality, and provides the best reference of custom bundled pricing strategy for rural areas, agriculture and farmers in China, which can help them to make better use of positive externality to set the custom bundled price of agricultural products. At the same time, the basic model of custom bundling pricing for products under positive externalities is given. In addition, the optimal custom bundling contract signed to achieve the expected when positive externality exists is discussed.
2. Custom Bundled Pricing Basic Model under Positive Externality

2.1. Basic Assumptions under Positive Externalities

In the agricultural product sales market, a company sells N similar agricultural products. Any initial cost of this N agricultural product is considered to be sunk cost and can therefore be not considered at the time of pricing, i.e. focus only on ex post-mortem efficiency. The consumer's budget is determined by the exogenous, and the consumer is heterogeneous, and its type is subject to a certain distribution of [k, K]. The net utility of a consumer's purchase of a bundle of agricultural products can be expressed as a linear utility function. Of these, n(k) represents the number of agricultural products in the agricultural bundles purchased by consumers, and Q represents the total number of agricultural products in the bundles consumed by all consumers, or total consumption. p(k) is the price corresponding to the bundle containing n(k) agricultural products, while W(n(k), k, Q) is the total utility that consumers receive from the purchase of the bundle.

If the positive externalities of the use or consumption of agricultural products are taken into account at this time, then when Q = 0, W(n(k), k, 0) means that the intrinsic value of the bundle obtained by the bundle of the k's purchase of n(k) agricultural products is equivalent to the utility obtained by only one of them when they purchase it. "The introduction of the modified model of the consumer utility function of Chuang and Sirbu (1999) to characterize the W(n(k), k, 0), i.e. W(n(k), k, 0) = s_o V(n(k), k) = s_o \int_{n=0}^{n(k)} \omega_o (1 - \frac{n}{K^N})dn \), where V(n(k), k) shows that different types of consumers have different preference sequences for the N agricultural products offered by monopoly firms. If n(k) < N, consumers actually buy bundles of their favorite n(k) produce. Correspondingly, type k indicates that the corresponding consumer evaluation of N agricultural products is a positive proportion. \omega_o says consumers' assessment of the most preferred agricultural product in the N-product. To simplify the analysis, assume that all consumers' preference parameters \omega_o are the same. The heterogeneity of the consumer is reflected in the parameter k. Type k \in [k, K], k > 0 and K > 1. This indicates that the K-type consumer's evaluation of all agricultural products is strictly positive. When Q > 0, the value obtained by consumers of type k buying the same bundle can be expressed as W(n(k), k, Q) = s_o V(n(k), k).

For the convenience of the label [4], use the subscript to indicate a derivative or bias of the variables or parameters corresponding to the subscript. For example, the first and second derivatives for the W(n(k), k, Q) on n(k), and the mixed bias derivatives for k and Q are represented as W'_o(n(k), k, Q), W'^o_o(n(k), k, Q), and W'^o_o(n(k), k, Q), respectively. Similar to the assumptions of standard nonlinear pricing in contract theory about consumer utility functions, and with reference to Sundararajan (2003)'s corresponding study hypothesis [1], the consumer utility function meets the following properties: (1) W'_o(n(k), k, Q) < 0; W'^o_o(n(k), k, Q) < 0, W'^o_o(n(k), k, Q) > 0. That is, the marginal utility of agricultural products in the bundle of consumer consumption decreases, the total utility of the same bundle of consumption increases by type, and the single cross-condition of Spence-Mirrlees is met. (2) M(k, Q) = \max_{n(k)} W(n(k), k, Q), and M(k, Q) is a finite positive number and unique. When n(k) < M(k, Q), W'_o(n(k), k, Q) > 0; when n(k) > M(k, Q), W'_o(n(k), k, Q) < 0. That is, consumers have a consumption cap that maximizes their utility, exceeding the limit, which puts consumers on negative marginal utility. (3) W'^o_o(n(k), k, Q) \geq 0, W'^o_o(n(k), k, Q) \geq 0,
$W_{sQ}(n(k), k, Q) \geq 0$. This shows that the total utility of consumers increases according to the total consumption in the agricultural market $Q$, reflecting positive externalities, while the marginal utility and type of marginal utility of consumption at the same time increase according to $Q$. (4) $W_{nA}(n(k), k, Q) \geq 0$, $W_{nk}(n(k), k, Q) \geq 0$. Similarly, $V(n(k), k)$ meets the following properties: a. $V_k(n(k), k) > 0$; b. $V_{nk}(n(k), k) > 0$; c. $V_{nn}(n(k), k) < 0$, i.e. $V(n(k), k)$ is strictly concave; d. Limited maximum purchase of agricultural products. Make $m(k) = \arg \max_{n(k)} V(n(k), k)$.

When $k \in [k, 1]$, $m(k) = kN$; if $k \in [1, \bar{k}]$, $m(k) = N$. If $n(k) < m(k)$, then $V_n(n(k), k) > 0$; while if $n(k) > m(k)$, then $V_n(n(k), k) < 0$. The distribution function of consumer type $k$: $F(k)$ and distribution density $f(k)$ are strictly greater than zero, and the inverse of the opportunity rate of type $k$ meets the decreasing condition $h(k) = \frac{1 - F(k)}{f(k)}$, $h_k(k) \leq 0$ $\forall k \in [k, \bar{k}]$. Rationality is a common knowledge, consumers know their type, because of information asymmetry, only observe the distribution of consumer types. In order not to lose generality, the total number of consumers in the market as a whole is generally reduced to 1.

2.2. Types of Contracts under Positive Externality
When there are positive externalities, it is likely that consumer expectations may be irrational due to differences in consumer expectations of total consumption of agricultural products, and even if all consumers have the same expectations, actual total consumption may not be consistent with the expected total consumption. Therefore, the classical positive externality literature assumes that consumers and can accurately predict the actual final total consumption, in order to reveal the positive externalities of the impact. This paper uses the idea of "macro-analysis method" proposed by Economides (1996) to describe positive externalities, i.e. the expectation of the consumer's total consumption is to achieve the expectation. Nevertheless, it is essential to distinguish between the following types of contracts to reflect the distinctions and linkages between achievable and non-achievable expectations, to lay the groundwork for the following analysis. For the sake of definition and comparison, assume that consumers are fully involved in the purchase of agricultural products at this time. Similar to Sundararajan (2003), defined as a class of three types of contract: (1) $s_p - Q$ feasible custom bundle contract - when the utility of each type of consumer using agricultural products is strictly higher than the retained utility zero, given any expected total consumption of agricultural products $Q$, the custom bundle contract $(n^F(x, Q), p^F(x, Q))$ that meets the consumer (IC) constraint and the (PT) constraint is called a viable contract, i.e. (IC) $k = \arg \max_x [W(n^F(x, Q), k, Q) - p^F(x, Q)] \quad \forall k \in [k, \bar{k}]$; (PT) $W(n^F(k, Q), k, Q) - p^F(k, Q) \geq W(n^F(k, Q), k, s_p, Q) - c^p n^F(k, Q) \quad \forall k \in [k, \bar{k}]$. (2) $s_p - Q$ optimal custom bundle contract - assuming that the same total consumption expectation same as the consumer, then for any given total consumption of agricultural products $Q$, when $s_p - Q$ feasible custom bundle contract $(n^F(x, Q), p^F(x, Q))$ can achieve the maximization of profit, it is called a $s_p - Q$ optimal custom bundle contract $(n(k, Q), p(k, Q))$, i.e. $\max_{n', p'} \int_{x} [p^F(x, Q) - cn^F(x, Q)] f(x) dx$ $\forall$ possible $(n^F(x, Q), p^F(x, Q))$ and $(n^F(x, Q), p^F(x, Q))$ to meet the consumer's (IC) constraints and (PT) constraints. When $s_p = 0$, the contract is called the $Q -$ optimal custom bundle contract. (3) $s_p - Q$ optimal can realize the expected contract - is the total agricultural consumption $Q$ can
achieve the expected \( s_p - Q \) optimal custom bundle contract \((n(k,Q), p(k,Q))\), so that the following conditions are established: a. \( Q = \int_2^k n'(k) f(k) dk \); b. \( n(k,Q) = n^*(k) \); c. \( p(k,Q) = p^*(k) \). then \((n^*(k), p^*(k))\) is called \( s_p - Q \) optimal to achieve the expected contract. When \( s_p = 0 \), the contract is called \( Q - \) optimal to achieve the expected contract. Based on the revision method of macro-analysis method based on the positive externality of Economides (1996)[3], the optimal custom bundling pricing strategy to be developed is actually a \( s_p - Q \) optimal to realize the expected contract.

3. Custom Bundle Pricing Strategy

3.1. Benchmark Custom Bundles without Positive Externalities

When there is positive externality in the use of agricultural products, the optimal custom bundle contract is equivalent to the \( Q - \) optimal contract when \( s_p = 0 \) can realize the expected contract. \( s_o V(n(k),k) = W(n(k),k,0) \). At this point, the retention effect for all consumers is zero. Therefore, the optimal custom bundled pricing contract in the absence of positive externalities can be used as the reference benchmark for the optimal realization of the expected contract when there is positive externality. Because the existence of positive externalities only makes the consumer's utility function contain an additional constant \( Q \), and does not affect the nature of custom bundle contract formulation, and \( s_o V(n(k),k) = W(n(k),k,0) \). Compared with Yang Jianman and so on (2004) on the product custom bundling pricing research, at this time the consumer utility function is only multiplied by a constant \( s_o \), so can be directly to develop the corresponding optimal agricultural products custom bundle pricing contract conditions and the optimal contract itself. In Lemma 1: Lemma 1 When there is no positive externality of product consumption, i.e. \( W(n(k),k,Q) = s_o V(n(k),k), \) if \( \bar{k} < \frac{s_o \omega_o}{s_o \omega_o - c} \), then the optimal custom bundling pricing contract

\[
(n^{NE}(k), p^{NE}(k))
\]

meets the following two conditions:

\[
\frac{s_o V_o(n^{NE}(k),k) - c}{s_o V_o(n^{NE}(k),k)} = h(k) \quad \forall k \in [\bar{k}, \tilde{k}]; \quad p^{NE}(k) = s_o V_o(n^{NE}(k),k) - \int_{\bar{k}}^{\tilde{k}} s_o V_o(n^{NE}(x),x) dx \quad \forall k \in [\bar{k}, \tilde{k}].
\]

At this point, all consumers are involved in the purchase of the product, and the optimal custom bundle contract can be uniquely developed as follows: \( n^{NE}(k,s_o) = \frac{(s_o \omega_o - c)kN}{s_o \omega_o(1 + \frac{h(k)}{k})} \);

\[
p^{NE}(k,s_o) = \frac{(s_o \omega_o - c)kN}{2s_o \omega_o(1 + \frac{h(k)}{k})^2} - \frac{2s_o \omega_o h(k)}{k} + s_o \omega_o + c
\]

. The corresponding optimal profit is:

\[
\pi^{NE}(n^{NE}(k,s_o), p^{NE}(k,s_o)) = \int_{\bar{k}}^{\tilde{k}} N (s_o \omega_o - c)^2 f(k) dk
\]

achieved their optimal consumption under the optimal incentive compatibility custom bundle pricing strategy, that is, \( n^{NE}(k) < kN \quad \forall k \in [\bar{k}, \tilde{k}]; \) \( n^{NE}(k) < N \quad \forall k \in [1, \tilde{k}] \).
3.2. Optimal Realization of Expected Contracts under Positive Externality

When there is positive externality in the consumption of agricultural products, different types of consumers enjoy different values. Since consumers are buying custom bundles formed by a number of similar agricultural products, and consumers buy different bundles, the size of positive externality is not only related to the total consumption of agricultural products, but also to the intrinsic value obtained by consumers as a result of the different sizes of agricultural products consumed. Based on the above analysis, the total utility obtained by consumers of type $k$ to purchase their most preferred $n(k)$ agricultural products can be expressed as:

$$W(n(k),k,Q) = s_o V(n(k),k) + \eta s_o V(n(k),k)Q = s_o V(n(k),k)(1 + \eta Q),$$

wherein, $\eta s_o V(n(k),k)Q$ is the value obtained when the total agricultural consumption is $Q$, $\eta$ is externality strength and $0 < \eta < 1$.

From simple analysis, it can be seen that $s_o V(n(k),k)(1 + \eta Q)$ at this time satisfies all the properties of the consumer utility function under positive externalities in the basic model. Thus, the conclusions of the benchmark custom bundling contract can be fully utilized.

In order to develop the optimal realization of the expected custom bundle contract introduced the actual total consumption function $G(Q)$:

$$G(Q) = \int_k^\infty n(k,Q)f(k)dk,$$

wherein, $n(k,Q)$ is the optimal bundle of the only $Q$–optimal custom bundle that corresponds to the expected total agricultural consumption $Q$. In order to be close to the actual situation of consumer consumption of agricultural products, set $Q$ as a limited non-negative number, its upper bound is $Q_{\text{max}}$, and $G(Q) > 0$, corresponding to $Q$ on the realization of the expected total consumption of the existence of the nature of Lemma 2 to describe. Lemma 2 If $Q \in \{Q0 \leq Q \leq Q_{\text{max}}\}$, and $G(Q)$ is the actual total consumption function, then when $G_Q(Q)$ is continuous and $0 < G_Q(Q) < 1$, $G(Q)$ is a compression map, and there must be a unique compression map not moving point $Q^* > 0$, making $G(Q^*) = Q^*$ the total consumption that can achieve the expected. According to Lemma 2, the $Q$–optimal can be expected to be customized bundles according to $G(Q)$, as described in Lemma 3: Lemma 3 If $G(Q) = Q$, then the corresponding $q$ optimal custom bundle contract $(n(k,Q), p(k,Q))$ for a $Q$–optimal can achieve the expected custom bundle contract $(n^*(k), p^*(k))$, satisfied with: (1) $n^*(k) = n(k,Q)$ ; (2) $p^*(k) = p(k,Q)$ .

If $\forall Q, n(k,Q)$, then the inequality conditions $k < \frac{s_o \omega_o(1 + \eta Q^*)}{s_o \omega_o(1 + \eta Q^*) - c} \quad$ and $0 < \eta [V_s(n(n(k,Q),k) - h(k)V_n(k)(n(k,Q),k)] < -V_{ss}(n(k,Q),k)(1 + \eta Q)$ are established, then the product use of positive externalities can be developed the only optimal can be achieved the expected custom bundle contract as follows:

$$n^*(k) = \frac{s_o \omega_o(1 + \eta Q^*) - c}{s_o \omega_o(1 + \eta Q^*)(1 + \frac{h(k)}{k})}.$$

At this time, can achieve the expected total consumption of agricultural products is: $Q^* \geq \int_k^\infty n^*(k)f(k)dk$, at the same time, the optimal realization of the expected custom bundle contract has the following nature $n^*(k) > n^{\text{NE}}(k), p^*(k) > p^{\text{NE}}(k) \quad \forall k \in [k,\tilde{k}]$. Since there is a positive correlation between the value of the consumer gaining value under positive externalities and the intrinsic value of the customized bundle of
agricultural products obtained and the realizable total consumption, positive externality not only increases the consumer's willingness to pay, but also promotes the purchase through the positive impact of total consumption on the total utility of consumers. This allows those who want to maximize profits to increase the quantity across the range when developing their optimal custom bundle contracts that can be expected - price pairs for each item on the menu to get more consumer surplus. The expected custom bundle contract adjustment can be achieved under positive externalities.

With the optimal quantity-price-to-menu all-round increase, economic intuition suggests that profits will certainly increase accordingly. You can get the corresponding optimal profit $\pi^*(n^*(k), p^*(k))$ for $\pi^*(n^*(k), p^*(k)) = \int_{k}^{k+1} N[k](s, w_n) \frac{1}{2} \left[ \frac{1}{k} \right] f(k) dk$. Because $[s, w_n(1 + \eta Q^*) - c]^2 / [s, w_n + c] > (s, w_n - c)^2 / (s, w_n)$, after comparison, $\pi^*(n^*(k), p^*(k)) > \pi_{NE}(n_{NE}(k), p_{NE}(k))$. This means that the consumer surplus $s(k)$ is $s(k) = \int_{k}^{k+1} V_s(n^*(x), x)(1 + \eta Q^*) dx \quad \forall k \in [k, \bar{k}]$ under the custom bundle contract which is indeed due to positive externality expectations. Depending on the nature of $V(n(k), k)$, we can see $V_{nk}(n(k), k) > 0$, then $n^*(k) > n_{NE}(k)$, so all consumers have an increase in surplus except for the $k$-type consumer's surplus. On the whole, positive externalities do improve overall social welfare. The existence of positive externalities in product use allows for the distribution of consumer value to society as a whole through the development of optimal customized bundles that can achieve expectations, and the improvement of social Pareto by simultaneously increasing profits with the surplus of all consumers (except the lowest end consumers).

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