Internal price decision in subcontracts

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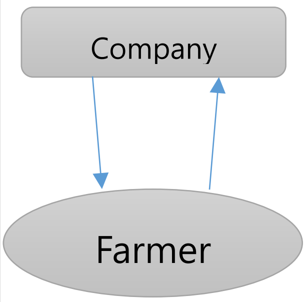
Motivation

Imagine a monopolistic chicken meat processing company. It receives its chicken from small farms across the country, which have made an exclusive contract with the company. After processing the meat, the company sells its products to consumers in the market. The exclusive contract between the company and farms includes conditions that prohibit the farms from selling their chicken to other companies or directly to the market. In turn, the company is obliged to provide the farms with eggs, feed and the latest chicken raising technology. Raising chicken without such assistance is highly unprofitable. Once a chicken is raised by a farm to meet certain standards, the company buys the meat at a supply rate internally fixed in the contract.

This setting can easily be applied without loss of generality to other subcontracting or outsourcing transactions such as the market for semi-conductors, pharmaceutics and so on.

It seems as though the contract above is a win for both company and farm. The company is supplied with chicken meat at a lower price, and the farm can procure a steady sales route in addition to a lower cost of production. However, further economic analysis is required in order to investigate who truly benefits from such contracts. It is also paramount to discuss whether such a contract is socially optimal. Since it is not, which will be shown in the following pages, a process of finding a better contract to improve social utility will ensue. The results of this study can potentially serve as a ground for legal action regulating related contracts.

-Provides eggs, chicken feed, and breeding technology.
N.b. Without these, chicken farming becomes highly unprofitable.



-Supplies raw chicken meat at a fixed contract price.
N.b. Farmer cannot supply other sources, such as other firms or direct market. I.e., the contract is exclusive.

1. Analyzing the contract

1-A. Sequential negotiation

In the previously mentioned setting, the chicken processing firm will have a demand for chicken, which is derived from the demand it faces for its processed products in the market. Thus, the firm will suggest a chicken farm ("Farmer") to sign a contract exclusively with the firm. Accordingly, the farmer will take a look at the contract, and choose to accept or decline the offer. If the farmer accepts the contract, the deal immediately goes into action. Otherwise, the deal is over, and nothing happens. This model can be seen as a sequential game, which can be solved using the concept of backwards induction and subgame perfect Nash equilibrium (SPE).

In this game, the corporation ("Company"), which is the leader will decide on a fixed supply rate x won/chicken. The farmer will accept or decline this suggestion, which in either way terminates the negotiation.

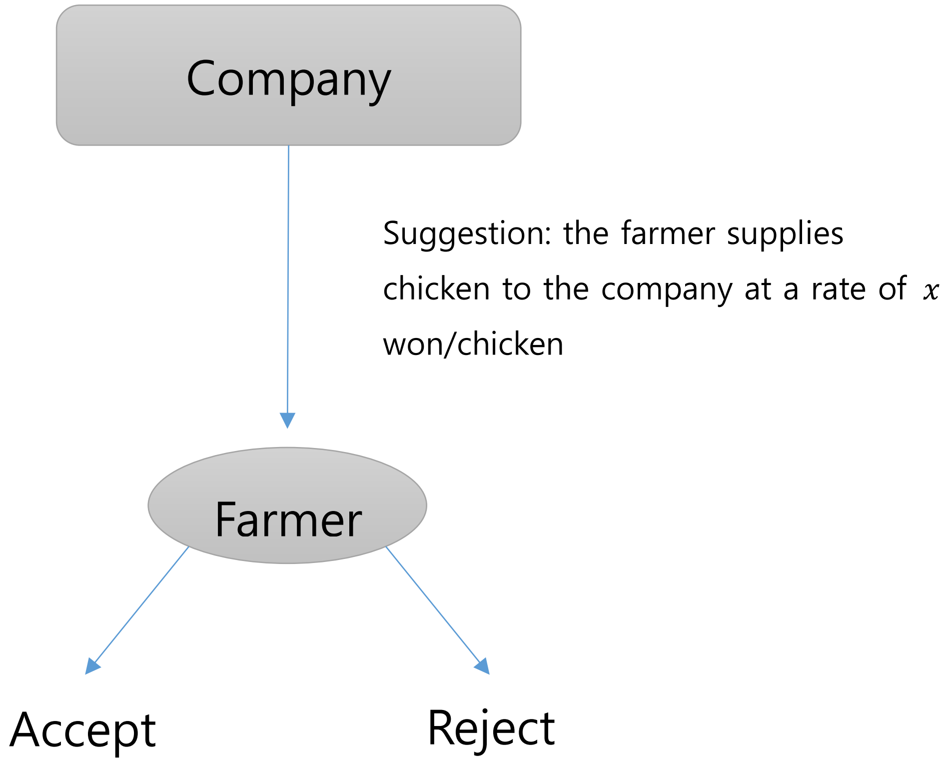
We will assume that given supply rate x won/chicken, the chicken farmer will produce $\mathrm{q(x)} = Ax$ amount of chicken. This can be seen as a factor supply function. Factor supply may bend backwards once x is sufficiently large, but for this specific model, we will assume a monotonically increasing factor supply function.

In addition, the inverse demand function the company faces in the processed chicken farm is $\mathrm{P(q)} = B - q(x)$.

We will further assume that the marginal production cost of the farmer is constant, that is: $\mathrm{mc} = \mathrm{c}$. Moreover, since the technology provided by the company makes the farmer more efficient, we can denote the marginal production cost of the farmer when he rejects the contract as c_0, and we can assume that $\mathrm{c} < c_0$. Also, set depreciation coefficient to zero.

Finally, let **a** be the market price of raw chicken meat the farmer faces if she declines the contract with the company.

The process of the game is depicted in the following diagram.



In the case the farmer accepts x, the payoff function will be equal to:

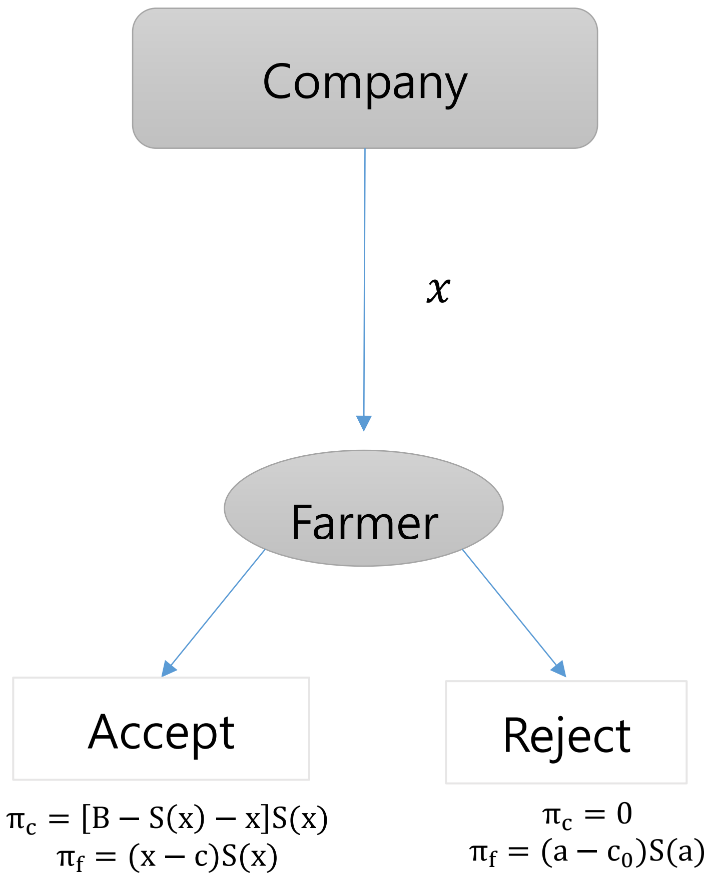
$$\pi_c = [B - S(x) - x]S(x)$$

$$\pi_f = (x - c)S(x)$$

In the case the farmer chooses to reject the offer, the payoff function is equal to:

$$\pi_c = 0$$

$$\pi_f = (a - c_0)S(a)$$



Using backward induction, the company knows that the farmer will accept any x that satisfies

$$(x-c)S(x) \geq (a-c_0)S(a)$$

Thus, the company will suggest x such that

$$(x-c)S(x) = (a-c_0)S(a),$$

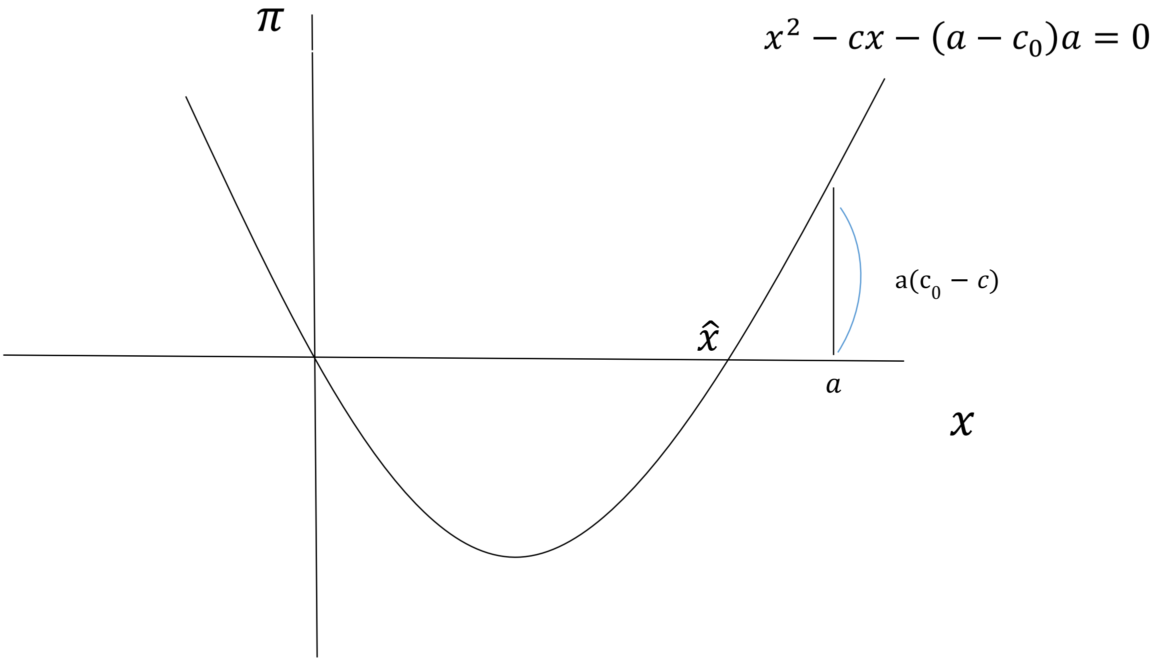
And the farmer will accept this offer.

We can sketch the above quadratic function through simple calculation.

$$(x-c)S(x) = (a-c_0)S(a)$$

$$(x-c)Ax = (a-c_0)Aa$$

$$x^2 - cx - (a-c_0)a = 0$$



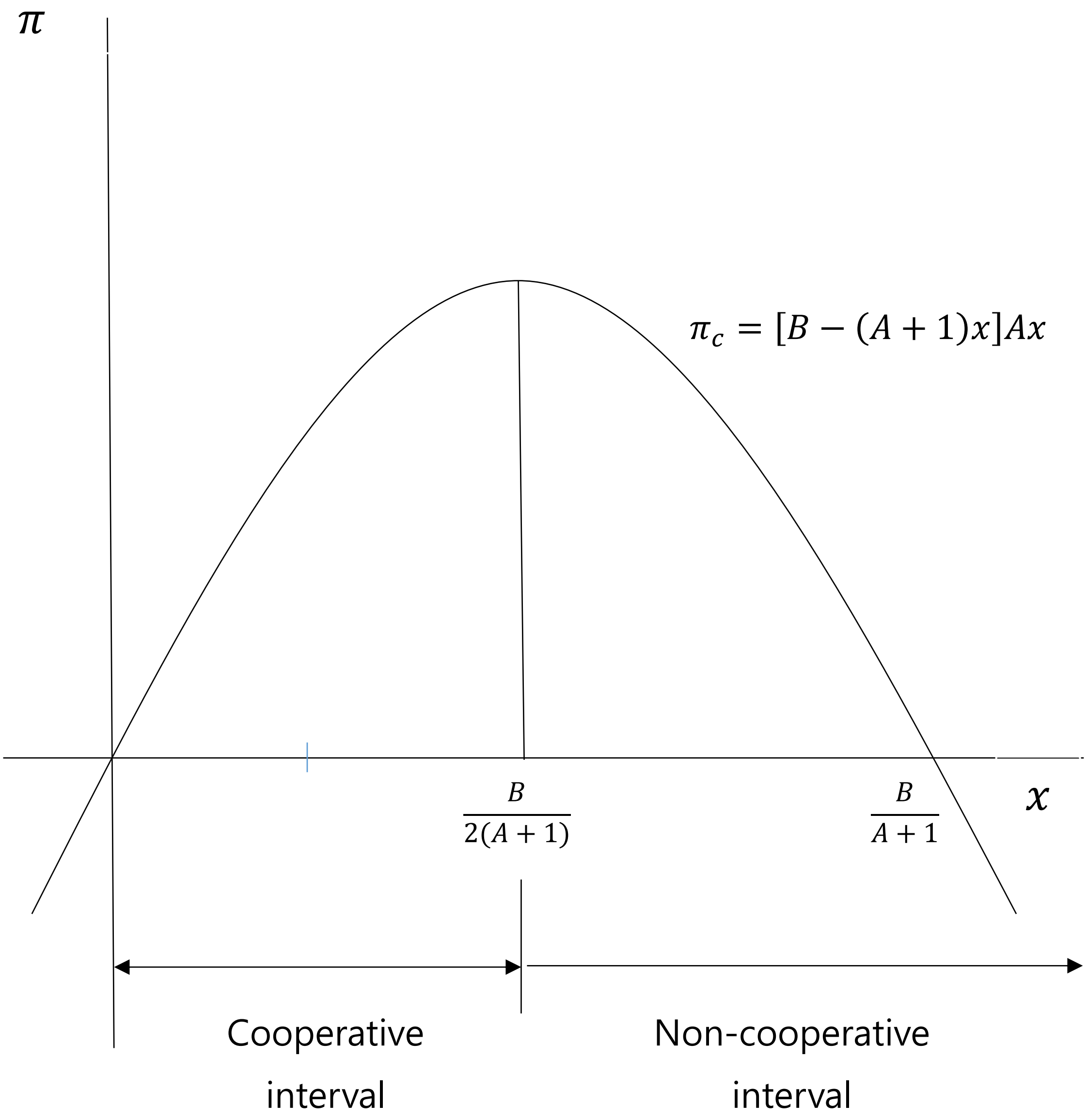
It is easy to verify that the point a would have been the root of this quadratic function, if $\mathrm{c} = c_0$. However, since $\mathrm{c} < c_0$, the function $\mathrm{x}^2 - \mathrm{cx} - (\mathrm{a} - \mathrm{c}_0)\mathrm{a} = 0$ can be seen as $\mathrm{x}^2 - \mathrm{cx} - (\mathrm{a} - \mathrm{c})\mathrm{a} = 0$ shifted upwards by $\mathrm{a}(\mathrm{c}_0 - c) > 0$

Thus, we can see that the image of a is clearly positive for this function. Also, since a was the larger root of $\mathrm{x}^2 - \mathrm{cx} - (\mathrm{a} - \mathrm{c})\mathrm{a} = 0$, the new root $\hat{x}$, which is the price that the company will suggest to the farmer, is always smaller than a.

The question whether the company will always choose $\hat{x}$ depends on the company's profit function.

That is, since $\hat{x}$ was chosen based by the company's decision to minimize the farmer's profit, it may not always guarantee maximum profit for the company. In other words, when the company can increase his profit by increasing x, then the interests of the company and farmer coincide and we will call this interval the cooperative interval. On the other hand, if increasing x decreases the company's profit, the company will wish to decrease x. We shall call this interval the non-cooperative interval.

Thus, it is crucial to know whether $\hat{x}$ is located in the cooperative, or non-cooperative interval. This is easily explained in the following graph.



Thus, the company selects $x = \begin{cases} \frac{B}{2(A+1)} & (when\ \hat{x} \in \left[0, \frac{B}{2(A+1)}\right]) \\ \hat{x} & (when\ \hat{x} \in \left[\frac{B}{2(A+1)}, \frac{B}{(A+1)}\right]) \end{cases}$

It is notable that $x < a$. This means, the farmer will accept a contract that gives her less than selling directly to the market. However, since $\mathrm{c} < c_0$, her profit becomes indifferent, and she will hence accept the contract.

This is quite an accurate explanation of what is happening in real life. Citing an article from 7/10/15 OhmyNews, Kim Donghwan: ***닭 한 마리 800원… '하림'만 배부른 세상*** , It can be shown that the internally decided unit price is 800 won per chicken. However, according to the *Monthly Agricultural Magazine* provided by KREI, the price in the raw chicken meat market, namely a, was 1727, 1542, 1248, 1397 won in the first, second, third, and fourth quarters of 2015 respectively. Clearly, this provides a solid ground that $x < a$ holds.

1-B. Assuming the company has multiple subsidiaries

In this case, all the previous assumptions are still valid. However, there is an additional assumption that the company is receiving a constant amount of chicken e from other subcontracted farms. The more farms that are contracted with the company, the greater the value of e.

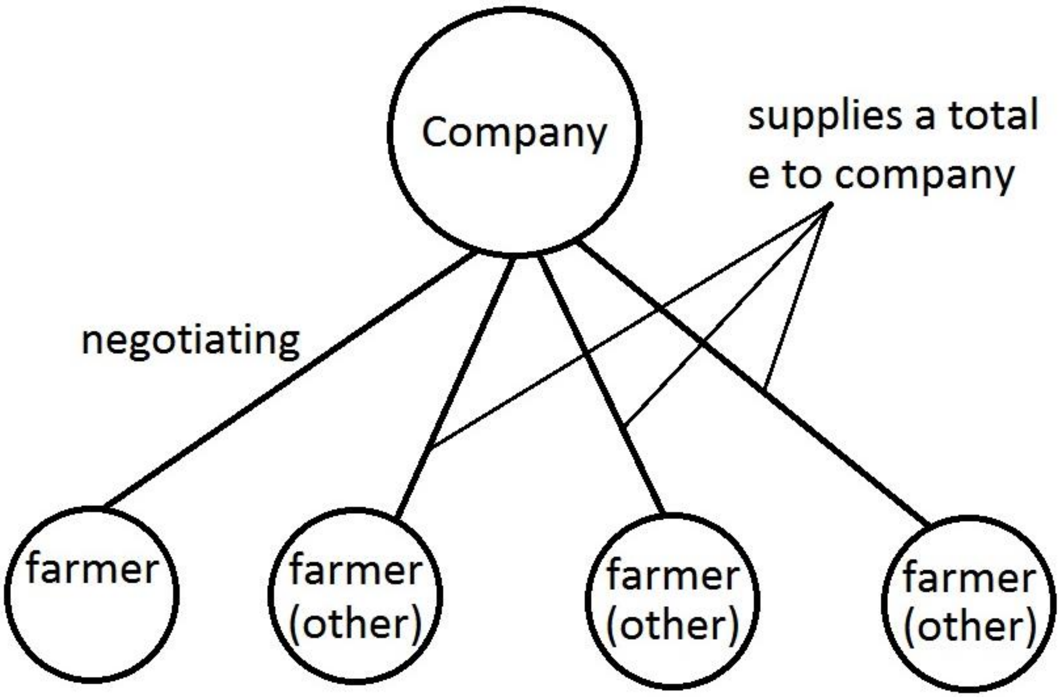


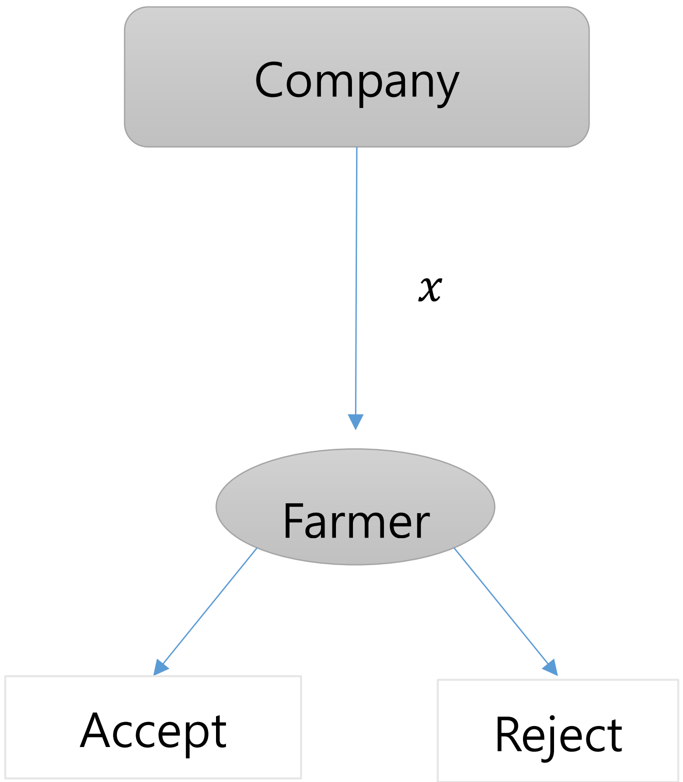
Figure 1

Now, note that the inverse demand function of processed chicken is

$$P(q) = B - e - q(x).$$

Consequently, the company will still be able to make $(B - e)e$ amount of profit even if the farmer rejects the contract.

Now, there is a change in the payoff vector.

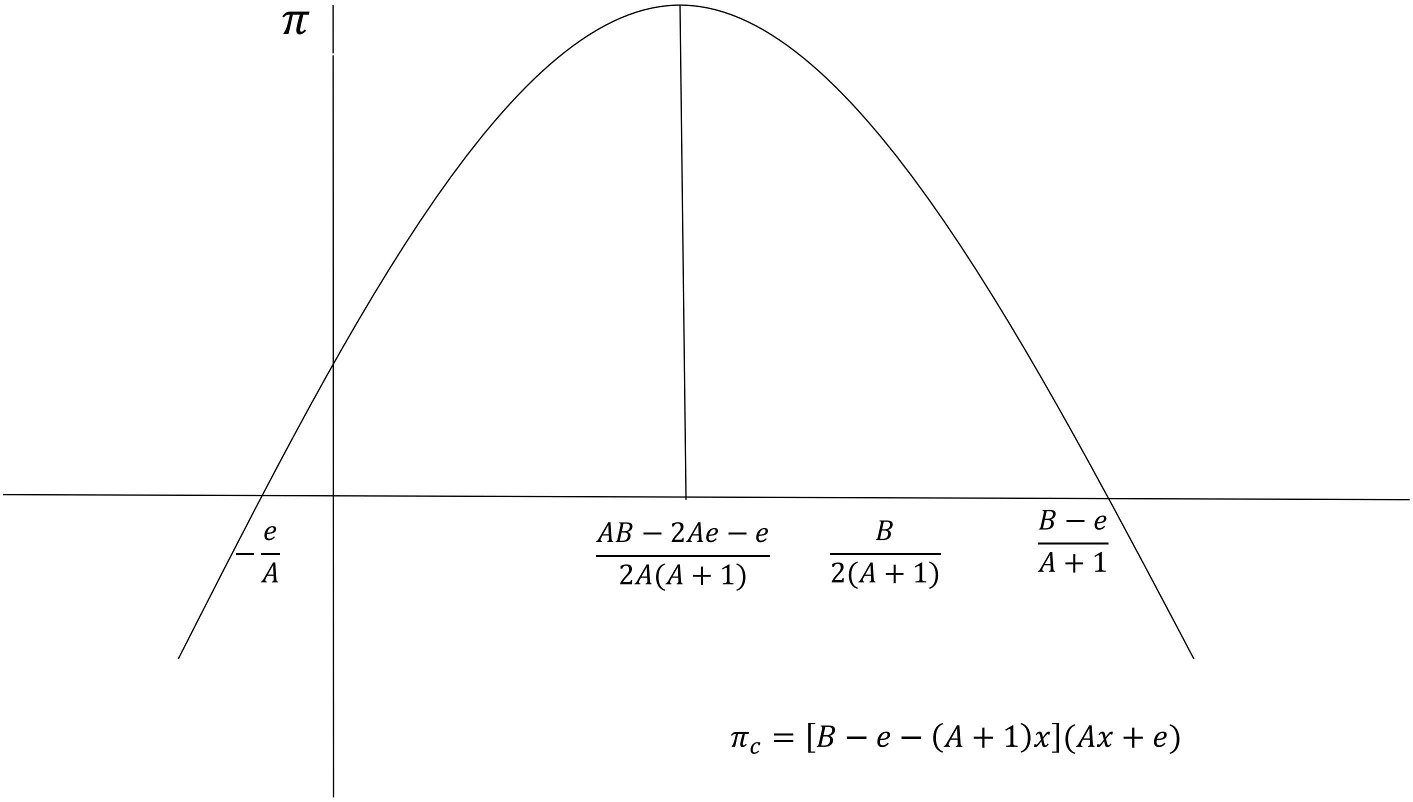


$$\pi_c = [B - e - S(x) - x](S(x) + e)$$
$$\pi_f = (x - c)S(x)$$
$$B > e + S(x)$$

$$\pi_c = [B - e - x]e$$
$$\pi_f = (a - c_0)S(a)$$

Once, more we can achieve a sketch of the company's payoff function through simple algebra.

$$\pi_c = [B - e - S(x) - x](S(x) + e)$$
$$= [B - e - (A + 1)x](Ax + e)$$



We can easily verify that

$$\frac{AB-2Ae-e}{2A(A+1)} < \frac{B}{2(A+1)}$$

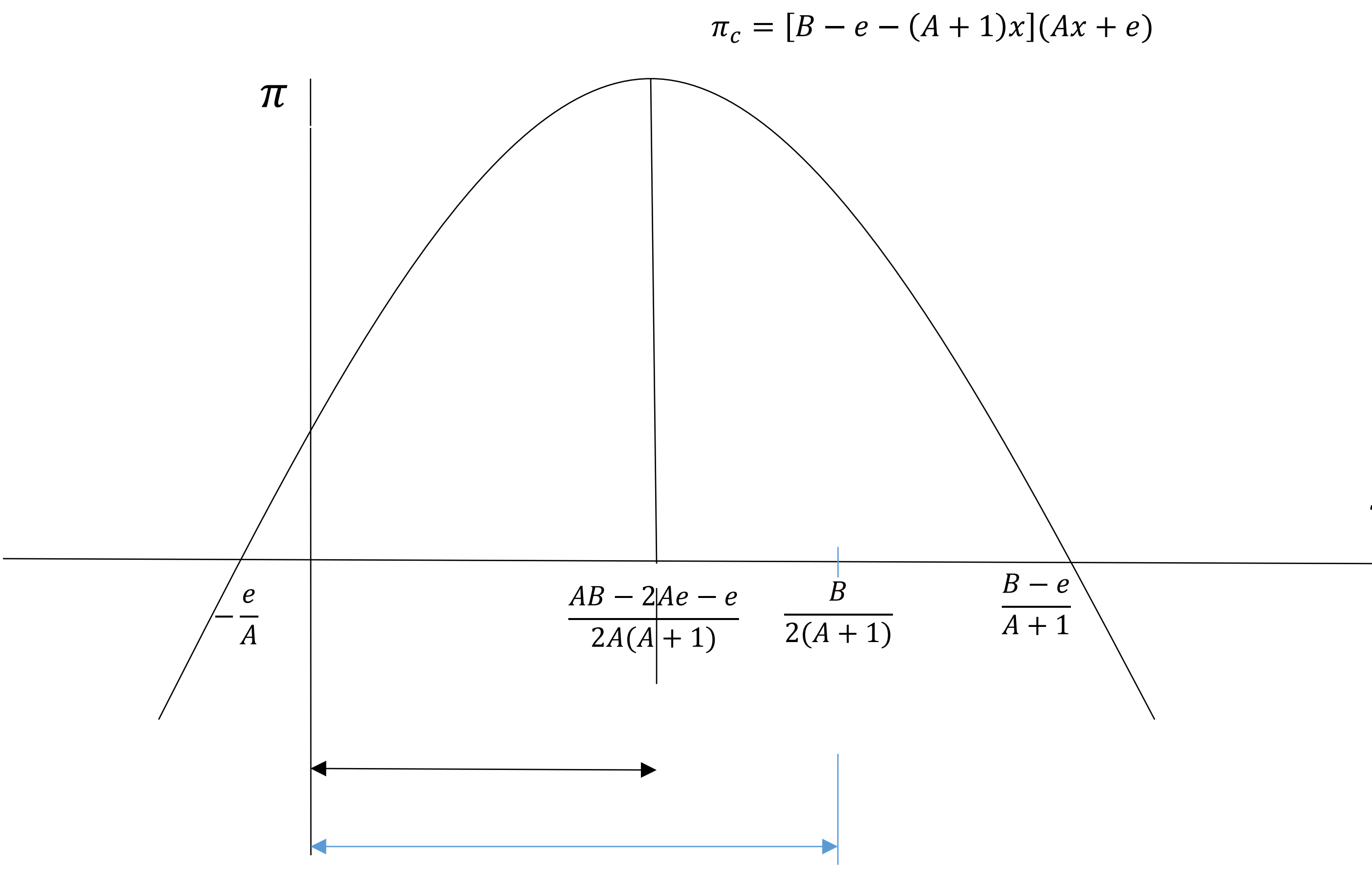
$$\because \quad \frac{B}{2(A+1)} - \frac{AB-2Ae-e}{2A(A+1)}$$

$$= \frac{1}{2(A+1)}\left[B - \frac{AB-2Ae-e}{A}\right]$$

$$= \frac{1}{2(A+1)}\left[2e + \frac{e}{A}\right] > 0$$

The implication here is that the cooperative interval has become shorter.

In other words, the company has an incentive to choose a lower price, which is clearly disadvantageous for the farmer.



This is notable, because companies having many subcontractors is not an uncommon phenomenon. Supporting this view, there also have been recent media coverage regarding the imbalance of supply rates between companies and their subcontractors. This model may provide some explanation for the underlying reason for this imbalance.

2. Improving social utility

2-A. Optimal contract price

From the previous section, it is understood that the subcontractors are in a disadvantageous position when deciding upon the supply rate of chicken. That is, the company lowers the supply rate as he gains more supply routes elsewhere.

In this section, given the same assumptions from the previous section, we will calculate the socially optimal contract price, based on the result of the previous section..

Since we assumed the farmer's supply function to be $S(x) = Ax$, the company's optimal choice of x is $x_c = \frac{AB-2Ae-e}{2A(A+1)}$. This can be achieved by maximizing the company's profit function.

It is quite clear that due to our assumption of $S(x) = Ax$, The farmer's optimal choice of x is unbounded. This is because the profit function of the farmer has no maximum value on $[0, \infty)$.

Assuming the society consists solely of the company and farmer, we can find the socially optimal x by maximizing the joint profit

$$max_x(\pi_c + \pi_f) = max_x[(B - e - Ax - x)(Ax + e) + (x - c)Ax]$$

This can easily be computed by setting the first order condition to zero.

$$\frac{d}{dx}(\pi_c + \pi_f) = A(B - e - (A + 1)x) - (A + 1)(Ax + e) + Ax + A(x - c)$$

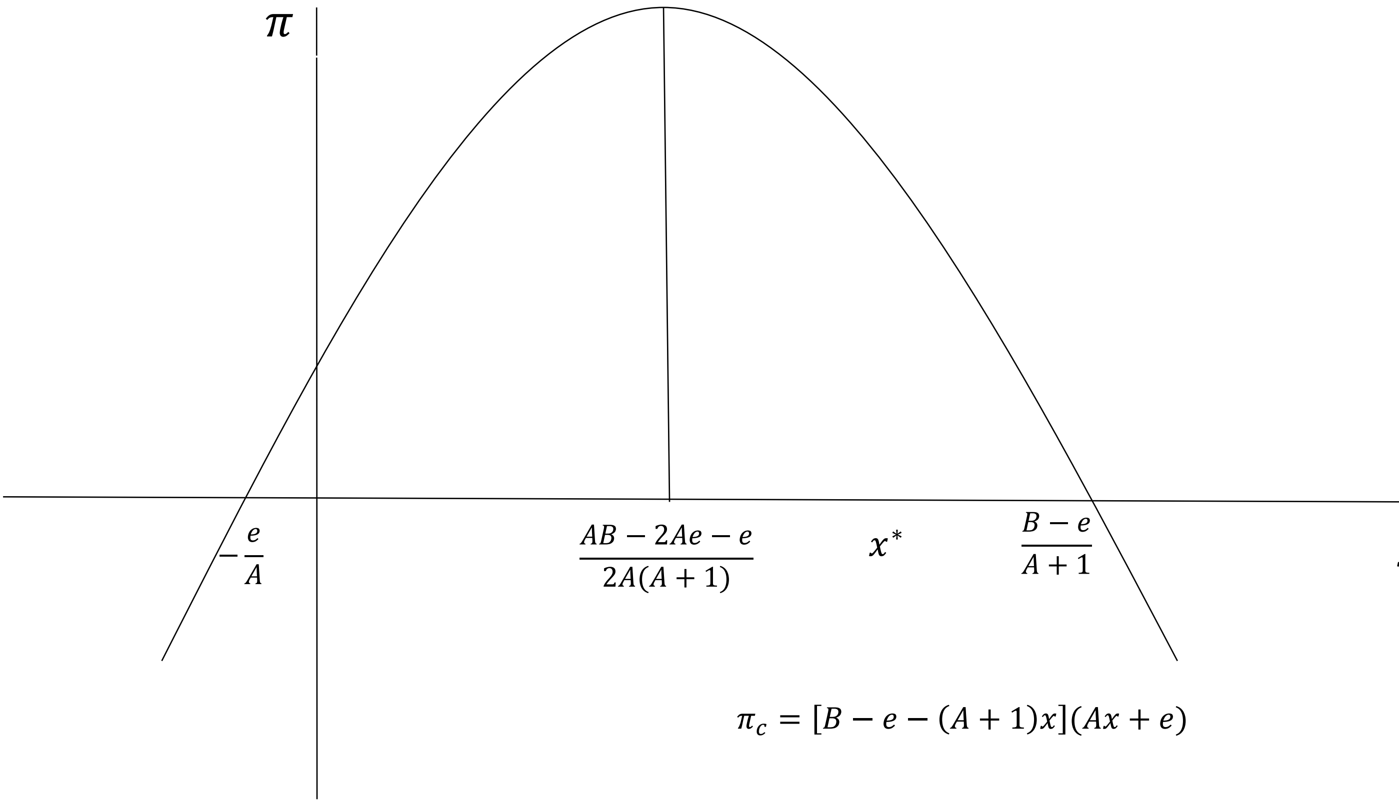
$$= -2A^2x + AB - 2Ae - e - Ac = 0$$

$$x^* = \frac{AB - 2Ae - e - Ac}{2A^2}$$

x^* indeed maximizes the social utility, because the second order condition is negative.

$$\frac{d^2}{dx^2}(\pi_c + \pi_f) = -4A < 0$$

Suppose $x^* \in \left[\frac{AB-2Ae-e}{2A(A+1)}, \infty\right)$. Then, it will be beneficial for the social utility to raise x when $\hat{x} < x^*$. On the contrary, it will be beneficial for the social utility to lower x when $\hat{x} > x^*$.



Hence, the government, whose objective is to maximize social utility will have an economic backing to enforce a policy for the contract between the company and farmer as the following

$$Policy = \begin{cases} raise\ internal\ price\ when\ \hat{x} < x^* \\ lower\ internal\ price\ when\ \hat{x} > x^* \end{cases}$$

Finding the exact location of x^*, or investigating Pareto efficiency could be included as a topic in a future study.

Also, generalizing $S(x)$ to any monotonically increasing function, and analysis on n periods with different a, with an uncertainty factor will be dealt with in the future.

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