

# Consumers Prefer Flexible Firms.

## A Note on 'Strategic Choice of Flexible Production Technologies and Welfare Implications.'

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Röller and Tombak (1990, RT henceforth) analyze the technological choice of two firms that must decide whether to serve one or two markets at the same time. By serving the two markets, a firm may increase its market share, and hence its profits. However, attacking one's competitor on her market stiffens competition. In this simple setup, RT show that, when fixed costs are small, market size is large, and products are imperfect substitutes, the two firms will adopt a flexible technology (or 'Flexible Manufacturing System' –FMS for short) in equilibrium. RT also demonstrate that this choice of FMS, like in a prisoners' dilemma, *reduces* the firms' equilibrium profits. Instead, consumers *always* benefit from this choice.

However, some technical issues were raised by Kim, Röller and Tombak (1992, KRT henceforth) and later by Gupta (1998). KRT demonstrate that one of the possible equilibria in RT cannot occur, unless mixed strategies are allowed for. Gupta (1998) uncovers some other mathematical inconsistencies and claims that some of RT's results are actually wrong. Namely, the welfare implications of FMS would be reverted for some parameter constellations.

In this note, we demonstrate that those three papers actually defined welfare in a way that is inconsistent with the consumers' utility function. Using appropriate welfare functions, we derive the correct welfare implications of the firms' decisions to invest in FMS. Our results show that, though based on incorrect mathematical premises, RT's results are correct, whereas Gupta's

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(1998) results are not. Expressed differently: the set of possible equilibria are consistent with KRT; consumers always benefit from the choice of FMS and –for some parameter constellations– coordinating the two firms away from the unique perfect equilibrium is *quasi*-Pareto improving.

In the remainder of this note, we only develop the mathematical part of our argument, and we let the reader refer to Röllner and Tombak (1990) for the economic motivation and the definition of the variables.

## Consumers and Consumer Surplus

The only acceptable definition for Consumer Surplus is the difference between 1) the utility derived from the consumption of the two goods ( $A$  and  $B$ ), and 2) total expenses:

$$CS = U(Q^A, Q^B) - p^A Q^A - p^B Q^B, \quad (1)$$

and we show below that the definition of  $CS$  used in the aforementioned papers is actually inconsistent with the utility function of the consumers:

$$U = \alpha(Q^A + Q^B) - \frac{1}{2} \left[ (Q^A)^2 + (Q^B)^2 + 2\lambda Q^A Q^B \right]. \quad (2)$$

From (1) and (2), one can derive the following inverse demand functions:

$$\begin{cases} p^A = \alpha - Q^A - \lambda Q^B, \\ p^B = \alpha - Q^B - \lambda Q^A. \end{cases} \quad (3)$$

Finally, using (2) and (3) into (1) and simplifying terms away yields:

$$CS = \frac{1}{2} \left[ (Q^A)^2 + (Q^B)^2 \right] + \lambda Q^A Q^B, \quad (4)$$

instead of the function ‘ $\frac{1}{2} \left[ (Q^A)^2 + (Q^B)^2 \right]$ ’, used by RT, KRT and Gupta.

## Firms’ Choices and Equilibrium Consumer Surplus

Firms can decide between two technologies. If both choose a “Dedicated Equipment” ( $DE$ ), firm 1 only produces goods  $A$  and firm 2 only produces goods  $B$ . When a firm chooses  $FMS$ , instead, it can produce the two types of goods. Once technology is chosen, firms compete in Cournot. Deriving equilibrium quantities for each pair of technologies, we can show that KRT’s results are correct. Moreover, substituting for equilibrium quantities in (4),

we compute the equilibrium consumer surplus given the technological choices of the firms (like in RT, we set  $t = \alpha - C$ ):

$$\begin{aligned} CS_{FMS,FMS} &= \frac{4t^2}{9(1+\lambda)} \\ CS_{Mixed} &= \frac{(25+7\lambda)t^2}{72(1+\lambda)} \\ CS_{DE,DE} &= \frac{(1+\lambda)t^2}{(2+\lambda)^2}, \end{aligned}$$

which allows us to show that:

**Proposition 1:** *Consumer surplus is always lowest when the two firms use Dedicated Equipment and highest when the two firms use FMS*

**Corrected Proof:** comparing consumer surpluses two by two:

$$CS_{FMS,FMS} - CS_{Mixed} = \frac{1-\lambda}{1+\lambda} \frac{7}{72} t^2 \geq 0$$

and

$$CS_{Mixed} - CS_{DE,DE} = CS = \frac{1-\lambda}{1+\lambda} \frac{28+12\lambda-7\lambda^2}{72(2+\lambda)^2} t^2 \geq 0$$

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## Implications for Total Surplus

Quite clearly, correcting the expression for Consumer Surplus also alters the definition of Total Surplus. Define  $TC(Q^A, Q^B)$  as total costs of producing the quantities  $Q^A$  and  $Q^B$ :

$$\begin{aligned} TS(Q^A, Q^B) &= U(Q^A, Q^B) - TC(Q^A, Q^B) \\ &= t \times (Q^A + Q^B) - \frac{(Q^A)^2 + (Q^B)^2}{2} - \lambda Q^A Q^B - F^T, \end{aligned}$$

and hence:

$$\begin{aligned} TS_{FMS,FMS} &= \frac{8t^2}{9(1+\lambda)} - 2(1+s) \\ TS_{Mixed} &= \frac{59+5\lambda}{72(1+\lambda)} t^2 - (2+s) \\ TS_{DE,DE} &= \frac{3+\lambda}{(2+\lambda)^2} t^2 - 2. \end{aligned}$$

These corrections do not qualitatively alter Proposition 3 in RT or in Gupta (1998), which remain valid even though the specifics of their proofs are inexact.

## References

- [1] Gupta, Sudheer, 1998, “A note on ‘Strategic choice of flexible production technologies and welfare implications’ ”, *Journal of Industrial Economics*, 46, 403.
- [2] Kim Taekwon, Lars-Hendrik Röller and Mihkel Tombak, 1992, “Strategic choice of flexible production technologies and welfare implications : addendum et corrigendum”, *Journal of Industrial Economics*, 40, 233-235.
- [3] Röller, Lars-Hendrik and Mihkel Tombak, 1990, “Strategic choice of flexible production technologies and welfare implications”, *Journal of Industrial Economics*, 38, 417-431.