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Intellectual property and antitrust limitations on contract: comment

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Abstract

In their chapter in Dynamic Competition and Public Policy (2001, Cambridge University Press), Burtis and Kobayashi never defined their model's discount rate, making replicating their simulation results difficult. Through our own simulations, we were able to verify their results when using a discount rate of 0.10. We also identified two new types of equilibria that the authors overlooked, doubling the number of distinct equilibria in the model.

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1 Introduction

Michelle Burtis and Bruce Kobayashi (2001) present an interesting model of the software industry. In our view, what is most interesting about this model is that it incorporates aspects of both Cournot and Schumpeterian competition, as well as variables that correspond with the strength of copyright and contractual protection for intellectual property. As the discussion surrounding the model demonstrates, the model is rich and relates to many issues in both antitrust and licensing.[2]

However, we have discovered some problems with their presentation. Most seriously, the discount rate was never defined, making replicating their simulation results difficult. Therefore we undertook our own simulations in an attempt to verify their results. The good news is that we were able to verify their results when using a discount rate of 0.10. But we also discovered two new types of equilibria that the authors overlooked, taking the number of distinct equilibria in the model from two to four. Two other minor issues, discussed below, also merit clarification.

We begin by briefly describing the model, and then go through our corrections point by point. We present our own simulation results, containing our newly identified equilibria, in the Appendix. In the model there are two types of firms, originators and imitators. Originators spend resources creating software programs and imitators spend resources copying these programs. Let N_O be the number of firms producing original software and N_I be the number of firms producing imitation versions of the source code.

Market demand is given by $P(Q) = 1 - N_O q_O - N_I q_I$, where q_O and q_i are the quantities produced by originators and imitators, and Q is the total quantity of software units produced and sold by both types of firms. Assuming marginal cost for originator and imitators is a_O and a_I respectively, it is straightforward to take the first-order conditions for profit maximization, solve for reaction functions assuming symmetry, and then to solve the resulting system of equations for the Cournot quantities for each type of firm.

At the time the decision to invest in producing an original or imitation version of the source code, the profit functions for each type of firm j (where $j = O, I$) equal:

$$\Pi_j = [P(Q) - a_j]q_j - F_j$$

where F_O and F_I are the fixed costs of original development and imitation, respectively.

In order to generate the simulation results reported in Table 1, Burtis and Kobayashi (2001) made specific assumptions about how z, the level of copyright protection, and k, the level of contractual protection, affect the cost of producing original and imitation versions of the source code. Specifically, they assumed that

$$F_O(z) = 0.4 + 0.05z$$

[2] Our discussion applies equally to the 2001 published version, and to the working paper version available at http://ssrn.com/abstract=210088, which seem to be essentially identical.

$$F_I(z) = 0.1 + 0.10z$$

$$a_O(k) = 0.01 - 0.001k$$

$$a_I(k) = 0.01 + 0.01k.$$

If we assume that the static per-period profits are collected in perpetuity, the present value of profits net of the costs of authorship or imitation turn out to be

$$\Pi_O^* = [(1 - a_O(1 + N_I) + N_I a_I)/(1 + N_I + N_O)]^2 / r - F_O$$

$$\Pi_I^* = [(1 - a_I(1 + N_O) + N_O a_O)/(1 + N_I + N_O)]^2 / r - F_I$$

where r is the discount rate.

The number of firms in the model is endogenously determined. Given the at least one version of the original source code exists, the marginal firm can choose to enter either with its own original version of the source code or with an imitation version of the source code. Thus, a distribution of firms is an equilibrium if the following set of conditions are met. First, imitation versions cannot exist in the absence of at least one original version of the source code. Second, further entry by either an original or imitation firm cannot be profitable. Third, no existing firm of one type can make higher profits by changing its decision on whether to produce an original or imitation version. Finally, all existing firms must expect that the present value of their investment in producing an original or imitation version of the software program is positive.

As mentioned above, we have identified several problems with Burtis and Kobayashi's (2001) presentation. We will now go through our (five) corrections point by point. First, there were errors in their equations (5) and (6). These equations did not include the marginal costs a_O and a_I.[3] Second, there were errors in their equation (14). Total welfare must include each originator's and imitator's profit in addition to the sum of all generated consumer surpluses.[4] Third, there was a minor typo in their equation (25).[5] Fourth, the discount rate was never defined, making replicating their simulation results difficult. Through our own simulations, we were able to verify their results when using a discount rate equal to 0.10. Finally, while we verified that all of their proposed equilibria in fact met the equilibrium conditions, we also identified two new equilibria. These new equilibria are indicated by an " * " in Table 1 in the Appendix. The cells in which these new equilibria exist are also shaded in Table 1.

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[3] These are the first-order conditions; the correct equations are:

(5) $q_O = [1 - (N_O - 1)q_O - N_I q_I - a_O]/2$

(6) $q_I = [1 - N_O q_O - (N_I - 1)q_I - a_I]/2.$

[4] The correct equation for total (or gross) welfare is:

(14) $TW^* = (1 - P^*(Q^*))(N_O q_O^* + N_I q_I^*)/2r + N_O \Pi_O^* + N_I \Pi_I^*.$

[5] The equation, with the correct notation, is as we reported above: (25) $a_I(k) = 0.01 + 0.01k$.

Of all of our corrections our fifth, that Burtis and Kobayashi (2001) underreported both the number and variety of equilibia, is in our view our most valuable contribution. On the whole, our findings indicate not only that their model is correct, but we also show that it is more interesting—the model supports a wider variety of equilibria than the original authors realized. In particular, they identified only two types of equilibria, and only one of these had imitator firm entry. This is strange for a model of the software industry where imitation is a rather prevalent phenomenon. However, the two additional equilibria that we discovered both have multiple imitator firms.[6] In one case there are two imitators and two originators, and in the other case there are three imitators and one originator.

2 References

Burtis, M. and Kobayashi, B. (2001) "Intellectual Property and Antitrust Limitations on Contract" in Dynamic *Competition and Public Policy: Technology, Innovation, and Antitrust Issues* by J. Ellig, editor, Cambridge University Press: New York, 229-263.

[6] To illustrate why these are in fact equilibria, consider first the equilibrium at z=1, k=8, where NO, NI=1, 3. This is an equilibrium, because the originator is making profit equal to 0.14, and imitators are making profit equal to 0.087 (i.e. both are making positive profits), further entry by an originator drives originator profit down (to -0.041), while further entry by an imitator drives imitator profit down (to -0.001); if an imitator switches to become an originator, his profit would go down to 0.07, while if the originator switches to become an imitator, his profit would fall to 0.139. The proof of the second equilibrium we discovered, at z=1, k=9, where NO, NI=2, 2, follows in a similar manner.

3 Appendix

Table I. Updated simulation results[7]

	A. (z = 0) *F_I = .10* *F_O = .40*	*B. (z = 1)* *F_I = .20* *F_O = .45*	*C (z = 2)* *F_I = .30* *F_O = .50*	*D. (z = 3)* *F_I = .40* *F_O = .55*	*E. (z = 4)* *F_I = .50* *F_O = .60*
I. (k = 0) *a_I = .010* *a_O = .010*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*
II. (k = 1) *a_I = .020* *a_O = .0095*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*
III. (k = 3) *a_I = .030* *a_O = .0090*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*
IV. (k = 4) *a_I = .040* *a_O = .0085*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	**NO, NI=3,0** **P = .256, Q = .74** **GW = 4.61** **NW = 2.81**
V. (k = 5) *a_I = .050* *a_O = .0080*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	**NO, NI=2,1** **P = .267, Q = .73** **GW = 4.61** **NW = 2.96**	**NO, NI=3,0** **P = .256, Q= .74** **GW = 4.61** **NW = 2.81**
VI. (k = 6) *a_I = .060* *a_O = .0075*	*No Equilibrium*	*No Equilibrium*	*No Equilibrium*	**NO, NI=3,0** **P = .256, Q = .74** **GW = 4.62** **NW = 2.97**	**NO, NI=3,0** **P = .256, Q = .74** **GW = 4.62** **NW = 2.82**
VII. (k = 7) *a_I = .070* *a_O = .0070*	*No Equilibrium*	*No Equilibrium*	**NO, NI=3,0** **P = .255, Q = .74** **GW = 4.62** **NW = 3.12**	**NO, NI=3,0** **P = .255, Q = .74** **GW = 4.62** **NW = 2.97**	**NO, NI=3,0** **P = .255, Q = .74** **GW = 4.62** **NW = 2.82**
VIII. (k = 8) *a_I = .080* *a_O = .0065*	*No Equilibrium*	**NO, NI=1,3*** **P = 0.249, Q = .75** **GW = 4.27** **NW = 2.87**	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 3.13**	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 2.98**	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 2.83**
IX. (k = 9) *a_I = .090* *a_O = .0060*	*No Equilibrium*	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 3.28** **NO, NI=2,2*** **P = .238, Q = .76** **GW = 4.42** **NW = 3.12**	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 3.13**	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 2.98**	**NO, NI=3,0** **P = .255, Q = .75** **GW = 4.63** **NW = 2.83**

[7] At the suggestion of an anonymous referee, we attempted to replicate the gross welfare (GW) and net welfare (NW) calculations. In this process, we discovered the errors in their equations (14) as mentioned in footnote 4 above. In addition, we found that Burtis and Kobayashi's report of GW and NW are off by a magnitude of 10, suggesting they forgot to include the discounted present value of consumer surplus. This can be quickly verified as $GW = NW + N_OF_O + N_IF_I$.