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Extending Monopoly Power under Joint Production: A Case Study of the Red Cross and the Blood Centers of America

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Abstract

This article provides a case study on joint production technologies in the market for blood products. The discussion and analysis are motivated by a patent for a plasma-scrubbing technology, acquired solely by the Red Cross. This example of joint production is used to illustrate questions surrounding the leveraging of monopoly power. Specifically, could the Red Cross utilize its monopoly over one jointly produced good (scrubbed plasma) to extend market power to a non-monopolized good (red blood cells) when competing with the Blood Centers of America? The case considers the potential for a dual monopoly (by the Red Cross in both markets), limit pricing on the part of the Red Cross in the market for red blood cells, and a shared market in which the Red Cross is a monopoly in the market for plasma but competes with the Blood Centers of America in the market for red blood cells.

KEYWORDS: joint production, patents, limit pricing, monopoly power

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1. INTRODUCTION

We present a case study on joint production technologies in the market for blood products. Blood products are an excellent example of joint production as whole blood, once harvested, can be broken down into plasma, red blood cells, white blood cells, and platelets, each of which are distinct products and are traded in distinct and independent markets. Our case study focuses attention on what might happen in the market for red blood cells if one of the two firms competing in the duopoly for red blood cells acquires a patent for producing plasma.

The basis for the case study hinges on a patent for a plasma-scrubbing technology that was acquired solely by the American Red Cross in 1997. The patented technology provided the Red Cross with a monopoly in the production (and sale) of plasma as the new "scrubbing" technology developed by V.I. Technologies would allow the Red Cross to produce plasma that was free of a variety of viruses. This example of joint production and the introduction of a patented technology is used to illustrate questions surrounding the leverage of monopoly power. Specifically, could the Red Cross exploit its monopoly over one jointly produced good (scrubbed plasma) to extend market power to a non-monopolized good (red blood cells) where it currently competes with the Blood Centers of America? The case considers the potential for a dual monopoly (in which case the Red Cross would act like a monopolist in both markets), limit pricing (in which case the Red Cross would aggressively price the Blood Centers of America out of the market for red blood cells), and a shared market (in which case the Red Cross would be a monopolist in the market for plasma but would compete with the Blood Centers of America in the market for red blood cells).

In the following section we describe the development of the scrubbed plasma technology by V.I. Technologies, the sale of this new technology to the Red Cross, and the suit filed by the US Department of Justice (with support from the Blood Centers of America and the Pentagon) on the grounds that the Red Cross might leverage its monopoly in the market for scrubbed plasma to gain an unfair advantage in the market for red blood cells. We then present a series of questions and answers in sections 3 – 5. In section 3, we provide a discussion of the underlying economic issues and pose questions designed to assist students in thinking about how best to model the problem and to develop their intuition concerning optimal firm behavior. We formally solve for a Nash equilibrium in section 4. In section 5 we discuss the efficiency implications of the solution, especially in terms of consumer and total surplus and in relation to possible antitrust actions. Because extending monopoly power requires "over-producing" in the competitive market, it is shown that consumer and total surplus are unambiguously higher when monopoly power is extended compared to having the government split the monopoly into two firms and prevent either from benefiting from the cost savings associated with joint production. Section 6 summarizes the exercise by tying it to the literature on leveraging that was initiated by Director and Levi (1956).

2. THE JOINT PRODUCTION OF BLOOD PRODUCTS – A CASE STUDY OF PLASMA AND RED BLOOD CELLS

In the 1990s, V.I. Technologies Inc. (VITEX), a biotech start-up, developed and patented a blood manufacturing process that kills lipid-enveloped viruses such as HIV and Hepatitis B and C in plasma, creating what is known as virally-inactivated plasma (or solvent-detergent plasma, marketed as SD plasma). In a nutshell, the technology works as follows. Detergents are added to plasma in such a way that allows the detergents to attach themselves to the fatty coatings of the viruses within the plasma. The detergents are then washed out of the plasma, carrying the viruses with them.[1] In 1997 the American Red Cross acquired the exclusive North American distribution rights of VITEX's virally-inactivated plasma. This agreement essentially provided the Red Cross with a monopoly in the market for plasma. While others could continue to provide "untreated" plasma, the Red Cross (and other blood providers) expected the market for untreated plasma to quickly evaporate as medical professionals would almost certainly refuse to use potentially virus-infected plasma when virally-inactivated plasma was available. The newly created monopoly in the market for plasma, however, was not the principle concern. This monopoly was the legitimate result of lengthy and costly research and development. The concern, at least to the Red Cross's competitors and to the US government, was whether the Red Cross would be able to leverage its monopoly in the market for plasma to gain an unfair advantage in the market for red blood cells.

In May of 1998, the approval of solvent-detergent plasma (SD plasma) by the US Food and Drug Administration came in the midst of a US Department of Justice (DOJ) antitrust investigation of the Red Cross, focused precisely on the Red Cross's exclusive contract with VITEX allowing it to produce SD plasma. The Blood Centers of America (BCA), a collection of independent blood banks with roughly half of the market for blood products, encouraged the DOJ's investigation. The main argument was that the Red Cross's agreement with VITEX would threaten BCA's ability to compete in the market for other blood products. At issue specifically was whether the patent over SD plasma would provide the Red Cross with a cost advantage due to the joint-production nature of blood products, and thereby also provide the Red Cross with the ability to limit

[1] The VITEX innovation does not remove viruses that are not coated by fat, such as Hepatitis A.

competition from the independent blood centers and possibly force them out of business. In short, the DOJ believed that the Red Cross could use the SD plasma monopoly to exploit other markets and secure a second monopoly due to the joint production of blood products.

It is interesting to note that the potential for the monopolization of other blood products was sufficiently concerning that the Pentagon joined the complaint. Prior to VITEX's technology for SD plasma, the Pentagon invested in the research and development of virus-free plasma. Eventually, however, the Pentagon considered VITEX's potential innovation to be of such promise that the Pentagon put its alternative technology on hold, awaiting VITEX's solvent-detergent plasma. Not surprisingly, the Pentagon was aggrieved by VITEX's decision to exclusively license the technology to the Red Cross and restarted research into its own technology.

The Red Cross vigorously defended its arrangement with VITEX, arguing that the Red Cross was devoted to the safest possible blood supply for the American public. Nevertheless, virally-inactivated plasma was priced at more than twice that of untreated plasma adding to the controversy surrounding the costs and benefits of the technology.

Ultimately, the DOJ investigation was shelved when an alternative plasma-scrubbing technology was developed, eliminating the Red Cross's short-lived monopoly. It is important to note, however, that the case was never closed and the potential for the same issue to arise in the future remains. Researchers and manufacturers continue to pursue technologies that would make blood products safer, reducing the risks of transfusions and eliminating additional pathogens. For example, VITEX is currently in the clinical trial stages of testing a new technology that removes pathogens from red blood cells. Thus, the potential for leveraging monopoly power across markets for different blood products remains.

Lastly, it is useful to know some rough institutional details about the markets for plasma and red blood cells. The American Red Cross and the Blood Centers of America each collect about 45 percent of all of the whole blood collected in the United States. Hospitals and military donor centers collect the remaining share. A unit of whole blood is equivalent to approximately 450 ml (about one pint). Whole blood is, by volume, made up of approximately 45% cellular elements (red blood cells, white blood cells, and platelets), while the remaining 55% of blood volume is plasma. Despite whole blood comprising mostly of plasma, the demand for blood products is dominated by a large market for red blood cells while the market for plasma is relatively smaller.

3. MODELING THE PROBLEM AND DEVELOPING INTUTION

Given the details presented above, the goal now is to provide an economic framework in which to assist in the DOJ's original antitrust investigation of the Red Cross. To do this, the problem must be simplified.

3.1. How should we model the market structure for plasma and for red blood cells?

The plasma scrubbing innovation effectively granted the Red Cross a monopoly in the market for plasma, while it continued to compete with hundreds of independent blood banks in the market for red blood cells. Although this structure might lead us to use a dominant firm model in the market for red blood cells, this is overly complicated and, possibly more importantly, doesn't allow us to take advantage of the well-known results concerning Cournot duopolies. Moreover, as the independent blood banks have formed an association (the Blood Centers of America), it is reasonable to assume that the Red Cross competes with a single entity in the market for red blood cells. Thus, the market structure we use assumes there are two firms – the Red Cross and the Blood Centers for America (BCA). The Red Cross is assumed to have a monopoly in the market for plasma, while the Red Cross and BCA are assumed to potentially be engaged in Cournot competition in the market for red blood cells.

3.2. How should we model technology?

Plasma and red blood cells are both derived from whole blood.[2] To keep things simple, assume that each unit of whole blood can produce one unit of red blood cells and one unit of plasma. Each firm begins by deciding how many units of whole blood to harvest. Thus, after harvesting q_{BCA} units of whole blood, BCA can choose to sell up to that many units of red blood cells. Letting q_{BCA}^{RBC} represent the number of units of red blood cells that it sells, BCA's technology requires that $q_{BCA}^{RBC} \leq q_{BCA}$. The Red Cross has a similar technology. After harvesting q_{RC} units of whole blood, the Red Cross can choose to sell up to that many units of red blood cells and up to that many units of plasma. Letting q_{RC}^{RBC} and q_{RC}^{plasma} represent the number of units of red blood cells and plasma that the Red Cross sells from its stock of whole blood respectively, the Red Cross's technology requires that $q_{RC}^{RBC} \leq q_{RC}$ and $q_{RC}^{plasma} \leq q_{RC}$.

[2] Whole blood is comprised of four elements: plasma, platelets, red blood cells and white blood cells. The case examined here focused on plasma and red blood cells. For simplicity and without loss of generality, we assume that these are the only two components extracted from whole blood.

One last important aspect of the technology concerns the possibility of not fully using all harvested whole blood. We assume that a firm can, if it wishes, costlessly dispose of the red blood cells or plasma from its stock of harvested whole blood. (In fact, BCA will never sell the plasma from its whole blood as the Red Cross holds a monopoly in the market for plasma.[3]) That is, a firm can opt to ***costlessly dispose*** of units of either good – red blood cells or plasma – that it elects not to sell. After making its total production decision, for example, the Red Cross is said to costlessly dispose in the market for plasma if $q_{RC}^{plasma} < q_{RC}$ and is said to costlessly dispose in the market for red blood cells if $q_{RC}^{RBC} < q_{RC}$.

3.3. How should we model the cost structure of the two firms?

The point of the investigation does not concern fixed costs or future research and development, so for our purposes, it is best to ignore both of these. Hence, neither firm has an R&D lab, and fixed costs are zero for both.

How we should treat marginal costs is less clear. There is a cost associated with harvesting a unit of whole blood, which is assumed to be similar across firms. Then there is an additional cost of separating the plasma from the red blood cells, which again is probably similar across firms. Both of these costs are marginal costs, and though they may differ, the point of the exercise is not to investigate how varying costs affect the opportunities to leverage monopoly power. Therefore, at least until the most basic model has been solved (at which point one may want to return to the problem and allow for more variability in the cost structure), the best approach is to assume the simplest cost structure that doesn't assume costs away. In particular, it will be assumed that both firms face a single, identical, fixed marginal cost of extracting and processing a unit of whole blood. In mathematical notation, each firm pays a constant marginal cost of c where $c \geq 0$ for each unit of whole blood that it harvests. Both firms can then extract up to one unit of red blood cells and one unit of plasma from each unit of harvested whole blood for free.

3.4. Will BCA ever find it optimal to costlessly dispose in the market for red blood cells?

BCA will never find it optimal to costlessly dispose of red blood cells. As BCA is only able to operate in one market (red blood cells) and as harvesting whole blood is costly, BCA will never over-harvest whole blood. In essence, BCA acts as if the marginal cost of producing each unit of red blood cells is always c.

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[3] Implicitly we are assuming that BCA cannot sell its plasma to the Red Cross.

3.5. Will the Red Cross ever find it optimal to costlessly dispose in both markets simultaneously?

The Red Cross will never costlessly dispose in both markets simultaneously as it is costly to harvest each unit of whole blood. As an example, if the Red Cross harvested 100 units of whole blood but only chose to sell 85 units of red blood cells (so chose to costlessly dispose of 15 units of red blood cells) and only chose to sell 80 units of plasma (so chose to costlessly dispose of 20 units of plasma), then the Red Cross could unambiguously increase its profits by 15c by harvesting only 85 units of whole blood originally and continuing to sell 85 units of red blood cells and 80 units of plasma.

3.6. In general, how might the solution look in terms of firm behavior? In particular, what pricing strategies might be optimal for the Red Cross?

There are three distinct outcomes or pricing strategies to the situation described so far, one with three cases to consider.

First, the Red Cross's monopoly in plasma may automatically grant the Red Cross a large supply of red blood cells, essentially for free, and the sale of some (or all) of its red blood cells naturally drives BCA out of the market. We will call this a ***Dual Monopoly***. It is important to note in the case of dual monopoly that the Red Cross is not engaged in limit pricing or predatory behavior. The dual monopoly is simply a result of having a cost advantage in the production in red blood cells, not in leveraging or exploiting its monopoly in plasma to create a cost advantage in red blood cells.

Second, the Red Cross may continue to compete with the BCA in the market for red blood cells while acting as a monopolist in the market for plasma. In this case, there are several cases to consider. Ultimately, the Red Cross could compete with BCA and in so doing (1) costlessly dispose of plasma, (2) costlessly dispose of red blood cells, or (3) not costlessly dispose of either product. These three cases, which on the surface appear to be separated by production decisions, can actually be directly linked to costs. In case (1), the Red Cross acts as if the marginal cost of a unit of plasma is zero while the marginal cost of a unit of red blood cells is c. Conversely, the Red Cross acts in case (2) as if the marginal cost of a unit of plasma is c while the marginal cost of a unit of red blood cells is zero. Finally, in case (3), the Red Cross acts as if the marginal cost of each unit of plasma and each unit of red blood cells is $c/2$ (more on this in section 4.) Depending on the sub-case, we will say that the Red Cross is engaged in ***Cournot Competition with Costless Disposal*** (of either plasma or red blood cells) or is engaged in ***Cournot Competition with No Disposal***.

Third, and most important in terms of analyzing the grounds for an antitrust investigation, the Red Cross could engage in predatory behavior vis-à-vis ***Limit Pricing*** in the market for red blood cells.[4] The Red Cross engages in limit pricing in the market for red blood cells if it "over-sells" in that market with the intention of getting BCA to withdraw from the market. In particular, the Red Cross over supplies the market for red blood cells to the point where the price per unit of red blood cells drops to at most *c*, as BCA can never make a profit at this price.

Except under special circumstances, it can be shown that a monopolist generally cannot extend its monopoly power across markets (see section 6). One such special circumstance arises in a dynamic setting with entry costs as a monopoly advantage in one market might be used to drive one's competitors from another market, allowing the firm to monopoly price in both markets in the future as large fixed entry costs deter future competition. Our case study of joint production between SD plasma and red blood cells is another special circumstance in which leveraging monopoly power might exist, and therefore is a case in which the DOJ may be concerned about anticompetitive practices.

Limit pricing is not the same as predatory pricing in a dynamic model. In a dynamic model, limit pricing and other predatory behavior can be profitable if it allows the predatory firm to capture future profits. In the problem considered here, the Red Cross may have an incentive to engage in limit pricing that does not stem from a dynamic extension. The model we have in mind is not a dynamic one with fixed (or entry) costs. That is, the Red Cross does not lower price today, driving BCA from the market, only to raise price tomorrow. Rather, in this model, the Red Cross might choose to engage in limit pricing in a non-dynamic setting because doing so increases its overall profit today. The source of this profit consideration is the joint production of the two goods. The answer to the following question pinpoints the economic motive of limit pricing under joint production.

3.7. Explain why the Red Cross can exploit its monopoly power by limit pricing in this model.

Engaging in limit pricing necessarily lowers the Red Cross's profits in the market for red blood cells. This is clear as the Red Cross can always engage BCA in Cournot competition in the market for red blood cells and earn positive profits, even if the Red Cross acts as if its marginal cost of production in the market for red blood cells is *c*. Thus, when the Red Cross limit prices in the market for red blood cells, it is lowering its profit *in that market* by setting the price of red blood

[4] There are legal issues surrounding limit pricing and other possibly predatory behaviors that we currently ignore.

cells equal to *c*. The Red Cross might elect to do precisely this, however, if it receives enough additional profit in the market for plasma. The question remains, what is the source of these additional profits in the market for plasma?

The marginal cost of harvesting a unit of whole blood is *c*, and when making its production decisions the Red Cross essentially decides how to distribute *c* over its two blood products. Because the Red Cross is a monopoly in the market for plasma but competes in the market for red blood cells, it is straightforward to show (as long as the production decisions remain in a certain range) that treating all of the costs as being associated with the production of red blood cells increases the Red Cross's profits in the market for plasma by more than it decreases its profits in the market for red blood cells. This is because a monopolist responds more dramatically to a decrease in its marginal cost than does a duopolist competing ala Cournot.[5]

Intuitively, this tradeoff centers on the value of the two markets. As the marginal cost of production increases, the markets become less valuable as the willingness to pay is fixed. Increases in marginal cost, therefore, reduce profits for both firms. This reduction in profits is more strongly felt in the red blood cell market, where the two firms compete. Thus, if the marginal cost of production is large enough, the value of the red blood cell market is quite small. It is in such a case that the Red Cross is more likely to find it valuable to forego all profits from the red blood cell market in order to increase profits in the plasma market.

There is also a market size consideration whenever dealing with joint production decisions. If one of the two markets is much larger than the other (recall that the market for red blood cells is much greater than the market for plasma), then joint production simply lowers the monopolist's overall costs as the firm must produce large amounts of output to satisfy demand in the large market, regardless of strategic tradeoffs that may exist between the two markets.

3.8. Should the US Department of Justice be concerned about anticompetitive practices by the Red Cross in the markets for plasma and/or red blood cells?

As the answer to question 3.7 suggests, limit pricing is most likely when the market for plasma is much more valuable than the market for red blood cells. If this were the case, the Red Cross might intentionally reduce its profits in the market for red blood cells in order to expand its profits in the market for plasma. Moreover, anticompetitive practices in an industry with two jointly produced goods are more likely when the two markets are of relatively the same size. It

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[5] Assuming identical costs and linear demand of the form $p = \alpha - q$, each firm's profit in the duopoly market is: $\pi_D = (\alpha - c)^2/9$ while a monopolist's profit is $\pi_M = (\alpha - c)^2/4$. Thus, an infinitesimal decrease in a duopolist's cost increases profits by only $2(\alpha - c)/9$ whereas it increases the monopolists profits by $(\alpha - c)/2$.

would appear, therefore, that the Red Cross would find it very difficult to exploit its cost advantage as market size dictates that it sell many more units of red blood cells than units of plasma. In short, the (joint) production of both goods must be valuable in order to leverage one's monopoly power. Thus, knowing that the market for red blood cells is larger and more valuable to the Red Cross than is the market for plasma, the DOJ should not be too worried about anticompetitive practices in the market for red blood cells. For further analysis suggesting that the DOJ should not have intervened, see Brooks and Lybecker (2007).

Section 5 provides a mathematical treatment of consumer and total surplus comparisons when the Red Cross is unregulated versus a DOJ intervention that protects the Red Cross's monopoly in plasma but prevents it from benefiting from joint production across markets. Even when the size of both markets and the demand for both products is identical, the results in section 5 show that consumer and total surplus are higher when the Red Cross is unregulated.

4. A COMPLETE MATHEMATICAL SOLUTION

In this section, we solve for a Nash equilibrium to a simple model of joint production in which the Red Cross (*RC*) and the Blood Centers of America (*BCA*) compete ala Cournot competition in the market for red blood cells, but the Red Cross is a monopolist in the market for plasma. The solution, which mirrors the intuition provided in section 3, is derived through a series of questions and answers in order to highlight the various cases associated with different cost levels. Technology and costs are modeled as indicated by the solutions to questions 3.2 and 3.3, and the assumption of costless disposal still holds. The solution is characterized completely in Table 1.

4.1. How should we model the demand for plasma and red blood cells?

This is an extremely important question, and it highlights the potential dissonance between the real world and economic modeling. Eventually one might want to allow for non-identical and/or non-linear demand for the two products (see Brooks and Lybecker, 2007) in order to more fully capture the reality of the markets such as apparent price differences across blood products and observing much greater demand for red blood cells than for plasma. That said, the first solution to the problem will greatly simplify demand by assuming that demand is linear and identical for both blood products. In particular, assume that both markets have a maximum willingness to pay of α and a total market demand (at a price of zero) of α as well. Thus, inverse demand for both products can be written as $p = \alpha - q$ where q is total industry quantity. Finally, assume $\alpha > c$ to ensure the existence of markets.

4.2. Provide mathematical descriptions of each firm's profit.

Denote by q_{RC} and q_{BCA} the units of whole blood harvested by the Red Cross and the Blood Centers of America respectively. Denote by q_{RC}^{plasma} and q_{RC}^{RBC} the number of units of plasma and red blood cells that the Red Cross elects to sell in each market subject to the technology constraints of $q_{RC}^{plasma} \le q_{RC}$ and $q_{RC}^{RBC} \le q_{RC}$. Let q_{BCA}^{RBC} denote the number of units of red blood cells that BCA decides to sell, and recall that profit maximization requires that $q_{BCA}^{RBC} = q_{BCA}$ as BCA will never costlessly dispose of red blood cells. Total market quantities are then q^{plasma} units of plasma and q^{RBC} units of red blood cells where $q^{plasma} = q_{RC}^{plasma}$ and $q^{RBC} = q_{RC}^{RBC} + q_{BCA}^{RBC}$. Similarly, let market clearing prices be denoted by p^{plasma} and p^{RBC} where $p^{plasma} = \alpha - q^{plasma}$ and $p^{RBC} = \alpha - q^{RBC}$. Profits for both firms are revenues less costs:

$$\pi_{RC} = p^{plasma} q_{RC}^{plasma} + p^{RBC} q_{RC}^{RBC} - c q_{RC} \text{ and } \pi_{BCA} = p^{RBC} q_{BCA}^{RBC} - c q_{BCA}.$$

4.3. What are the parameters of the model, and how should one think about solving for a Nash equilibrium?

The model has two parameters, α and c. To find a Nash equilibrium, one must consider the entire parameter space. In this case, we know that $0 \le c < \alpha$. Thus, one approach to completely solving for an equilibrium is to fix α and let c range from 0 to α.

4.4. The Red Cross is a dual monopolist if, by acting like a monopolist in both markets (but not engaged in limit pricing), BCA elects not to sell any red blood cells. Under what parameter restriction(s) is the Red Cross a dual monopolist?

Suppose the Red Cross is a dual monopolist. Without loss of generality, suppose that the Red Cross maximizes its profit by costlessly disposing of red blood cells (i.e., $q_{RC}^{RBC} < q_{RC}^{plasma} = q_{RC}$). Given identical demand in the markets for plasma and red blood cells, the Red Cross's marginal revenue in the market for plasma is less than its marginal revenue in the market for red blood cells as $q_{RC}^{plasma} > q_{RC}^{RBC}$. At the same time, the marginal cost of supplying more output to the red blood cell market is zero as the Red Cross is costlessly disposing of red blood cells. Taken together, these conditions contradict the claim that the Red Cross is maximizing its profits by costlessly disposing of red blood cells – the Red Cross should either increase sales of red blood cells if the marginal revenue of doing so is positive (as the marginal cost of doing so is zero), or it should restrict sales (and overall production) in the market for plasma if marginal revenue in red blood cells equals zero as marginal revenue in the plasma market is then negative but the marginal cost is c. Thus, when the Red Cross is a dual monopolist, it will always sell the same amount of output in both markets.

Now, as a dual monopolist that doesn't costlessly dispose of either product, the Red Cross chooses q_{RC} and sells the entire quantity in both markets. Its profit are then

$$(1) \qquad \pi_{RC} = p^{plasma} q_{RC} + p^{RBC} q_{RC} - c q_{RC} = (2\alpha - 2q_{RC} - c) q_{RC} .$$

Setting the first order condition equal to zero and solving for q_{RC} yields:

$$(2) \qquad q_{RC} = q_{RC}^{plasma} = q_{RC}^{RBC} = \frac{2\alpha - c}{4} = \frac{\alpha - (c/2)}{2} .$$

Using these quantities, the market clearing prices are: $p^{plasma} = p^{RBC} = (2\alpha + c)/4$. Notice that the right-most quantity expression in equation (2) reveals that the monopolist acts as if its marginal cost is $c/2$ in both markets. This result is expected as the Red Cross will want to treat each market identically which, in this case, requires the firm to split the marginal cost of production equally across markets. Any other treatment of marginal cost would lead the Red Cross to over-produce (under-produce) in the market that it associates with the lower (higher) cost.

Lastly, the demand and cost conditions that allow for the Red Cross to be a dual monopolist must be determined. The conditions for dual monopoly are simple: if the quantity that the Red Cross would supply to the market for red blood cells in the absence of competition from BCA is such that it drives the price of red blood cells to be at most c, then the Red Cross will always act like a monopolist in the market for red blood cells and BCA will never produce. The price of red blood cells when the Red Cross is a dual monopoly, $p^{RBC} = (2\alpha + c)/4$, is less than or equal to c when $c \geq 2\alpha/3$. Thus, the Red Cross is a dual monopoly whenever $c \geq 2\alpha/3$. (The complete parametric solution under dual monopoly is presented under the ***Dual Monopoly*** column of Table 1.)

Table 1. The Complete Solution

	Cournot Competition, Costless Disposal	Cournot Competition, No Disposal	Limit Pricing	Dual Monopoly
Range of c	$0 \le c < \alpha / 5$	$\alpha/5 \le c < 9\alpha/17$	$9\alpha/17 \le c < 2\alpha/3$	$2\alpha/3 \le c$
q_{RC}^{plasma}	$(\alpha-c) / 2$	$(3\alpha-c) / 7$	$(\alpha-c)$	$(2\alpha-c) / 4$
q_{RC}^{RBC}	$(\alpha+c) / 3$	$(3\alpha-c) / 7$	$(\alpha-c)$	$(2\alpha-c) / 4$
q_{BCA}^{plasma}	0	0	0	0
q_{BCA}^{RBC}	$(\alpha-2c) / 3$	$(2\alpha-3c) / 7$	0	0
q^{plasma}	$(\alpha-c) / 2$	$(3\alpha-c) / 7$	$(\alpha-c)$	$(2\alpha-c) / 4$
q^{RBC}	$(2\alpha-c) / 3$	$(5\alpha-4c) / 7$	$(\alpha-c)$	$(2\alpha-c) / 4$
p^{plasma}	$(\alpha+c) / 2$	$(4\alpha+c) / 7$	c	$(2\alpha+c) / 4$
p^{RBC}	$(\alpha+c) / 3$	$(2\alpha+4c) / 7$	c	$(2\alpha+c) / 4$
π_{RC}	$(\alpha-c)^2 / 4 + (\alpha+c)^2 / 9$	$2(3\alpha-c)^2 / 49$	$C(\alpha-c)$	$(2\alpha-c)^2 / 8$
π_{BCA}	$(\alpha-2c)^2 / 9$	$(2\alpha-3c)^2 / 49$	0	0
CS^{plasma}	$(\alpha-c)^2 / 8$	$(3\alpha-c)^2 / 98$	$(\alpha-c)^2 /2$	$(2\alpha-c)^2 / 32$
CS^{RBC}	$(2\alpha-c)^2 / 18$	$(5\alpha-4c)^2 / 98$	$(\alpha-c)^2 /2$	$(2\alpha-c)^2 / 32$
Total CS	$[9(\alpha-c)^2 + 4(2\alpha-c)^2]/72$	$[(3\alpha-c)^2 + (5\alpha-4c)^2]/98$	$(\alpha-c)^2$	$(2\alpha-c)^2 / 16$

4.5. Ignoring the possibility of limit pricing, show that the Red Cross will never maximize its profits by costlessly disposing of plasma.

The proof will be by counter-example. Suppose that the Red Cross maximizes profits by costlessly disposing of plasma (i.e., $q_{RC}^{plasma} < q_{RC}^{RBC} = q_{RC}$). The Red Cross will increase sales of plasma until marginal revenue for plasma equals zero (which requires $q_{RC}^{plasma} = \alpha/2$ under the standard monopoly solution with marginal costs set to zero) and costlessly dispose of its remaining output that it could otherwise sell in the market for plasma. Holding fixed BCA's output decision and recognizing that the marginal cost of red blood cells for the Red Cross is c, the Red Cross's profit in the market for red blood cells is $(\alpha - q_{RC}^{RBC} - q_{BCA}^{RBC} - c) \cdot q_{RC}^{RBC}$, yielding a best response function of $q_{RC}^{RBC} = (\alpha - c - q_{BCA}^{RBC})/2$. The Red Cross's optimal amount of output to sell in the market for red blood cells, therefore, is less than α/2 as *c* and q_{BCA}^{RBC} are both non-negative. But this contradicts the assumption that $q_{RC}^{plasma} < q_{RC}^{RBC}$ as $q_{RC}^{plasma} = \alpha/2$ when the Red Cross is costlessly disposing of plasma. Thus, costlessly disposing of plasma cannot be profit-maximizing for the Red Cross.

4.6. Ignoring the possibility of limit pricing, under what parameter restriction(s) will the Red Cross maximize profits by costlessly disposing of red blood cells?

Suppose the Red Cross maximizes its profits by costlessly disposing of red blood cells (i.e., $q_{RC}^{RBC} < q_{RC}^{plasma} = q_{RC}$). In this case, the Red Cross's profit from plasma is $(\alpha - q_{RC}^{plasma} - c) \cdot q_{RC}^{plasma}$ so that solving the first order condition yields the well-known monopoly solution of $q_{RC}^{plasma} = (\alpha - c)/2$ and $p^{plasma} = (\alpha + c)/2$. Given that the Red Cross is costlessly disposing of red blood cells, profits accruing to the two firms from selling red blood cells (at least on the margin) are $\pi_{RC}^{RBC} = (\alpha - q_{RC}^{RBC} - q_{BCA}^{RBC}) \cdot q_{RC}^{RBC}$ and $\pi_{BCA}^{RBC} = (\alpha - q_{RC}^{RBC} - q_{BCA}^{RBC} - c) \cdot q_{BCA}^{RBC}$. The respective first order conditions yield the optimal output quantities: $q_{RC}^{RBC} = (\alpha + c)/3$ and $q_{BCA}^{RBC} = (\alpha - 2c)/3$. Profits for the two firms are then easily calculated:

(3) $$\pi_{RC} = \frac{(\alpha - c)^2}{4} + \frac{(\alpha + c)^2}{9}$$

and

(4) $$\pi_{BCA} = \frac{(\alpha - 2c)^2}{9}.$$

Finally, by definition, the Red Cross costlessly disposes of red blood cells only if $q_{RC}^{RBC} < q_{RC}^{plasma}$, which requires that (α + *c*)/3 < (α – *c*)/2 . Solving for the requisite condition reveals *c* < α/5. Thus, the Red Cross costlessly disposes in the market for red blood cells only if *c* < α/5. (The complete parametric solution when the Red Cross costlessly disposes of red blood cells is presented under the ***Cournot Competition, Costless Disposal*** column of Table 1.)

4.7. Ignoring the possibility of limit pricing, it has been shown that the Red Cross maximizes profits by not disposing of either product when α/5 ≤ c < 2α/3. Solve for the optimal quantities, prices, and profits for both firms when this is the case.

Since the Red Cross does not costlessly dispose of red blood cells, $q_{RC}^{plasma} = q_{RC}^{RBC} = q_{RC}$, and as always $q_{BCA}^{RBC} = q_{BCA}$. The profit functions for the firms are then:

$$\text{(5)} \qquad \pi_{RC} = (p^{plasma} + p^{RBC} - c)q_{RC} = (2\alpha - 2q_{RC} - q_{BCA} - c)q_{RC}$$

and

$$\text{(6)} \qquad \pi_{BCA} = (p^{RBC} - c)q_{BCA} = (\alpha - q_{RC} - q_{BCA} - c)\, q_{\text{BCA}}.$$

Using the first order conditions to find best response functions and solving for the optimal quantities yields:

$$\text{(7)} \qquad q_{RC} = (3\alpha - c)/7 \text{ and } q_{BCA} = (2\alpha - 3c)/7.$$

Notice that BCA's optimal quantity equals zero precisely at the upper level of the interval for c, that is when $c = 2\alpha/3$, which is the threshold value at which the Red Cross becomes a dual monopolist. The market clearing prices can be determined directly:

$$\text{(8)} \qquad p^{plasma} = \alpha - q_{RC} = (4\alpha + c)/7 \text{ and } p^{RBC} = \alpha - q_{RC} - q_{RC} = (2\alpha + 4c)/7.$$

Finally, it is straightforward to calculate profits:

$$\text{(9)} \qquad \pi_{RC} = \frac{2(3\alpha - c)^2}{49}$$

and

$$\text{(10)} \qquad \pi_{BCA} = \frac{(2\alpha - 3c)^2}{49}.$$

(The complete parametric solution under competition when the Red Cross doesn't costlessly dispose in either market is presented under the ***Cournot Competition, No Disposal*** column of Table 1.)

4.8. Under what parameter restriction(s) will the Red Cross engage in limit pricing?

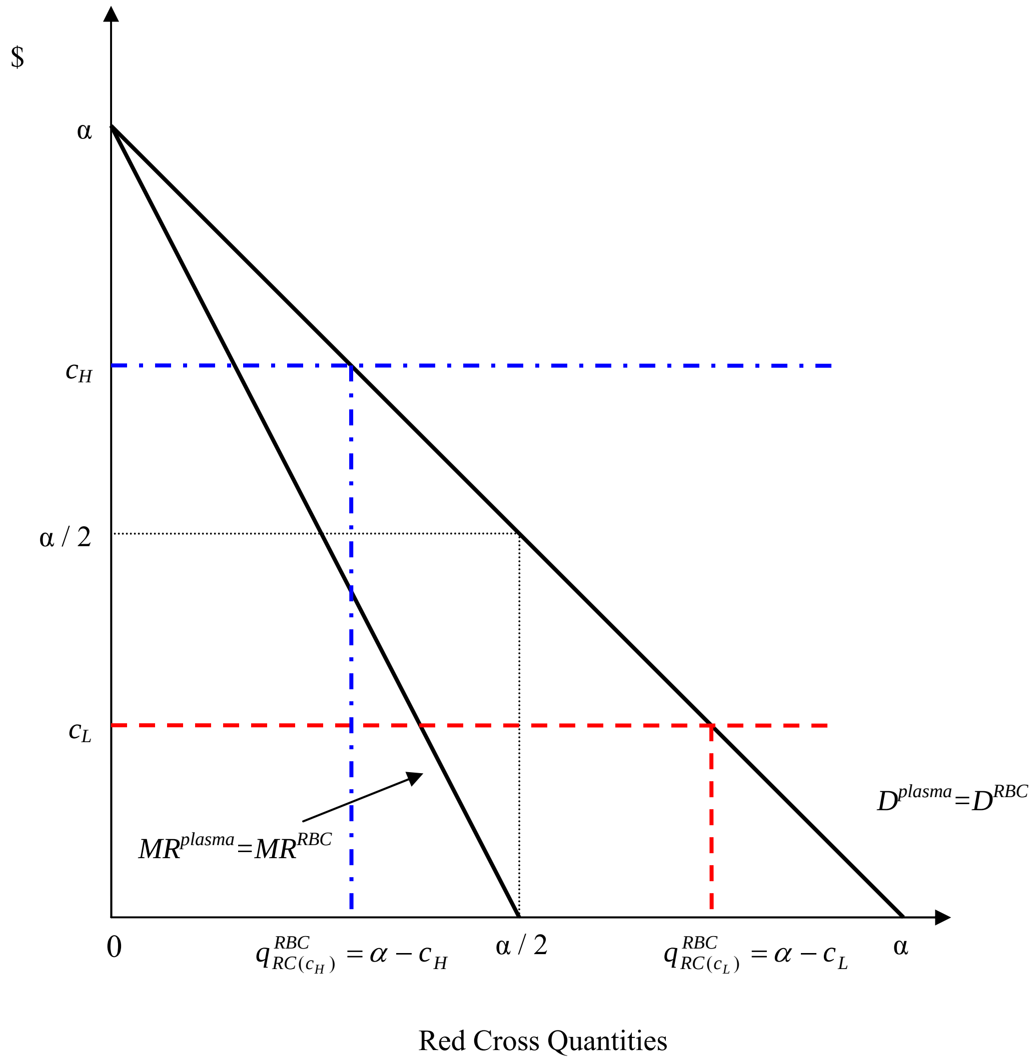
The Red Cross engages in limit pricing by increasing output in the market for red blood cells in order to drive the price of red blood cells low enough to just deter entry by BCA, which requires driving p^{RBC} down to c. It follows immediately that neither firm receives positive profit in the red blood cell market when the Red Cross engages in limit pricing. Specifically, under limit pricing, it must be that $q_{RC}^{RBC} = \alpha - c$ and $q_{BCA}^{RBC} = 0$. Moreover, notice that limit pricing results in the efficient quantity being sold in the market for red blood cells, despite the Red Cross's joint production capabilities of the two goods, even if the production of red blood cells is thought of as having a constant marginal cost of c.

Knowing the Red Cross's output decision in the market for red blood cells under limit pricing allows us to determine the Red Cross's behavior in the market for plasma. Figure 1 shows the Red Cross's possible decisions under limit pricing. Recall that the Red Cross engages in limit pricing by increasing sales of red blood cells so that the price falls to c. This means that for any c between 0 and α, q_{RC}^{RBC}, which equals $\alpha - c$, is found by extending a horizontal line from c (on the y-axis) over to the demand function and then straight down to find the Red Crosses quantity (on the x-axis) of red blood cells. Figure 1 shows this explicitly for two hypothetical costs, c_H (high cost) and c_L, (low cost) which are associated with production levels of $q_{RC(c_H)}^{RBC}$ and $q_{RC(c_L)}^{RBC}$. In both cases, because of the stipulated demand curve, $q_{RC}^{RBC} = \alpha - c$. Given identical demand functions for plasma and red blood cells, Figure 1 can now be used to determine the Red Cross's optimal behavior in the market for plasma by recognizing that the Red Cross's marginal cost for plasma equals zero as long as $q_{RC}^{plasma} \leq q_{RC}^{RBC}$ and equals c if $q_{RC}^{plasma} > q_{RC}^{RBC}$.

Suppose the marginal cost of production is less than α/2 (e.g., $c = c_L$ in Figure 1), so that the Red Cross produces more than α/2 units of red blood cells (e.g., $q_{RC(c_L)}^{RBC} = \alpha - c > \alpha/2$ in Figure 1). In this case, the Red Cross behaves as if the marginal cost of plasma equals zero and therefore increases sales of plasma until its marginal revenue from plasma equals zero by selling $q_{RC}^{plasma} = \alpha/2$ units of plasma and costlessly disposing of the rest. Accordingly, the Red Cross receives profit of:

$$\pi_{RC} = \alpha^2 / 4. \quad (11)$$

Figure 1. The Red Cross's Quantities under Limit Pricing



Alternatively, when the Red Cross faces a marginal cost that is greater than α/2 (e.g., $c = c_H$ in Figure 1), the Red Cross produces less than α/2 units of red blood cells (e.g., $q^{RBC}_{RC(c_H)} = \alpha - c < \alpha/2$ in Figure 1). In this case, the Red Cross's marginal cost for plasma is equal to zero for the first α – *c* units of plasma and is *c* for all additional units. Moreover, Figure 1 shows that whenever the marginal cost is greater than α/2, the Red Cross's marginal revenue in the market for plasma is above zero but below *c* at $q^{RBC}_{RC} = \alpha - c$. Accordingly, the Red

Cross's optimal behavior when engaged in limit pricing is to set q_{RC}^{plasma} equal to q_{RC}^{RBC} (which is equal to $\alpha - c$). In this case, the Red Cross is not costlessly disposing in either market, and its profits are:

(12) $$\pi_{RC} = c(\alpha - c).$$[6]

At this point, we must compare profits under limit pricing versus not limit pricing. There are three ranges to check: (1) $0 \le c < \alpha/5$ so that a firm not engaged in limit pricing would choose to costlessly dispose of red blood cells while a firm engaged in limit pricing would choose to costlessly dispose of plasma; (2) $\alpha/5 \le c < \alpha/2$ so that a firm not engaged in limit pricing would choose to not costlessly dispose but a firm engaged in limit pricing would costlessly dispose of some of its potential plasma; and (3) $\alpha/2 \le c < 2\alpha/3$ so that neither a limit-pricing nor a non-limit-pricing firm would choose to costlessly dispose.

When $0 \le c < \alpha/5$, the difference in profit between when the Red Cross engages in Cournot competition and costlessly disposes of red blood cells (equation 3) and when the Red Cross engages in limit pricing and costlessly disposes of plasma (equation 11) is:

(13) $$\frac{(\alpha - c)^2}{4} + \frac{(\alpha + c)^2}{9} - \frac{\alpha^2}{4}.$$

The first derivative of this difference with respect to c shows that the difference is always decreasing as long as $c < 5\alpha/13$. Moreover, when $c = \alpha/5$, the difference equals $7\alpha^2/100$, which is positive. Therefore, when $0 \le c \le \alpha/5$, the Red Cross maximizes it profits by competing with BCA in the market for red blood cells and not by limit pricing.

When $\alpha/5 \le c < \alpha/2$, the difference in profit between when the Red Cross engages in Cournot competition and doesn't costlessly dispose of either product (equation 9) and when the Red Cross engages in limit pricing and costlessly disposes of plasma (equation 11) is:

(14) $$\frac{2(3\alpha - c)^2}{49} - \frac{\alpha^2}{4}.$$

[6] It is interesting to note that while the Red Cross might costlessly dispose in the market for red blood cells when it competes with BCA in the market for red blood cells, if the Red Cross limit prices in the market for red blood cells then it would only consider costlessly disposing in the market for plasma.

The first derivative shows that this difference is decreasing as long as $c < 3\alpha$, which is always the case in the relevant range. Moreover, when $c = \alpha/2$, the difference equals $\alpha^2/196$, which is positive. Therefore, when $\alpha/5 \leq c < \alpha/2$, the Red Cross maximizes its profits by competing with BCA in the market for red blood cells and not by limit pricing.

When $\alpha/2 \leq c < 2\alpha/3$, the difference in profit between when the Red Cross engages in Cournot competition and doesn't costlessly dispose of either product (equation 9) and when the Red Cross engages in limit pricing and doesn't costlessly dispose of either product (equation 12) is:

$$(15) \qquad \frac{2(3\alpha - c)^2}{49} - c \cdot (\alpha - c).$$

It is easy to verify that this difference equals zero when $c = 9\alpha/17$ and again when $c = 2\alpha/3$. Moreover, the difference is positive when $c < 9\alpha/17$ and is negative when $9\alpha/17 \leq c < 2\alpha/3$. Therefore, limit pricing is an optimal strategy for the Red Cross in this latter range. That is, the Red Cross will engage in limit pricing (and in doing so, not costlessly dispose of either product) rather than compete with BCA in the market for red blood cells when $9\alpha/17 \leq c < 2\alpha/3$. (The complete parametric solution under limit pricing is presented under the ***Limit Pricing*** column of Table 1.)

5. ANTITRUST AND SURPLUS CONSIDERATIONS

Surplus comparisons for this model are not obvious because society always benefits from the innovation (i.e., scrubbed plasma provides surplus that wasn't available before) and the joint production nature of the Red Cross's technology makes comparisons across markets difficult. We will restrict our surplus comparisons, therefore, to one special case. The results detailed in Table 1 will be termed the results under the "innovation." These outcomes will then be compared to a particular hypothetical intervention that could be proposed by the US Department of Justice. In particular, assume the DOJ intervenes in the market by splitting the Red Cross into two firms – firm RC-P that has a patent in the market for plasma and firm RC-RBC that competes with BCA in the market for red blood cells. Firms RC-P and RC-RBC cannot interact with one another, nor can they take advantage of the cost savings associated with the joint production technology. Thus, the DOJ protects the Red Cross's patent in the market for plasma, but does not allow the Red Cross to benefit from joint production. We will call this the DOJ's "intervention."

Before making surplus comparisons, notice that the DOJ's intervention is fairly crude in that it forces society to bear a cost of *c* for every unit of output produced in each market. We show below that restricting the DOJ's intervention to these particular actions is bad for consumers and bad for society regardless of *c*. This potential intervention for the DOJ, however, seems to be a good baseline for comparison. If eliminating the joint production benefits accrued to the Red Cross makes consumers and society worse off, perhaps the DOJ should not proceed with an antitrust action even if the alternative is to have a market (for red blood cells) that appears to be less competitive than it otherwise could be.

5.1. Suppose the US Department of Justice accuses the Red Cross of engaging in predatory behavior whenever its quantity in the market for red blood cells is higher than it otherwise would be if the Red Cross didn't benefit from joint production. Under this definition, for what values of c would the DOJ accuse the Red Cross of predatory behavior?

Without the innovation, the Red Cross always competes with BCA in the market for red blood cells, with each firm producing $(\alpha - c)/3$ units of red blood cells, which is the standard identical cost solution to a Cournot duopoly. This is also how many units of red blood cells each firm would produce if the DOJ split the Red Cross into two distinct firms following the innovation. The q_{RC}^{RBC} row of Table 1 shows that the Red Cross always produces more red blood cells under the innovation than it would produce if the DOJ split it into two firms. Thus, under the stated criteria, the Red Cross would be considered to be engaged in predatory behavior under the innovation for all values of *c*.

5.2. Suppose the US Department of Justice accuses the Red Cross of engaging in predatory behavior whenever price in the market for red blood cells is higher than it otherwise would be if the Red Cross didn't benefit from joint production. Under this definition, for what values of c would the DOJ accuse the Red Cross of predatory behavior?

Without the innovation, the Red Cross always competes with BCA in the market for red blood cells. The standard Cournot solution for a duopoly has both firms producing $(\alpha - c)/3$ units of red blood cells, which leads to a market clearing price of $(\alpha + 2c)/3$. The p^{RBC} row of Table 1 shows that the price of red blood cells is always lower when the Red Cross benefits from the innovation than it would be if the DOJ split the Red Cross into two firms. Thus, the Red Cross would never be considered to be engaged in predatory behavior under the stated criteria regardless of the value of *c*.

5.3. Provide a graph of consumer surplus summed across the two markets under the proposed DOJ intervention (i.e., the creation of two firms, RC-P and RC-RBC, that cannot benefit from joint production) relative to the consumer surplus realized when the Red Cross is allowed to benefit from the joint production innovation. Provide a second graph of relative total surplus. Discuss what these graphs reveal. Hint: to make the graphs manageable, fix α at 1 and let* c *range from 0 to 1.

The results under the proposed DOJ intervention are the results under standard Cournot competition. In the market for plasma, firm RC-P produces $(\alpha - c)/2$ units of plasma, each unit sells at a market clearing price of $(\alpha + c)/2$, and consumer surplus and total surplus are $(\alpha - c)^2/8$ and $3(\alpha - c)^2/8$ respectively. In the market for red blood cells, firm RC-RBC and BCA both produce $(\alpha - c)/3$ units of red blood cells, each unit sells at the market clearing price of $(\alpha + 2c)/3$, and consumer surplus and total surplus in are $2(\alpha - c)^2/9$ and $4(\alpha - c)^2/9$ respectively.

Holding α fixed at 1, Figures 2 and 3 show the value of consumer surplus and total surplus under the DOJ's intervention relative to respective surplus values under the innovation. Notice that consumer surplus and total surplus are identical under the DOJ intervention and under the innovation when $c = 0$. This must be the case as $c = 0$ implies that the Red Cross does not benefit from joint production directly (which the DOJ intervention prevents) but does benefit from the monopoly (which the DOJ intervention protects). Figures 2 and 3 show that consumers and society are unambiguously better off under the innovation, and increasingly so as c increases. Again, this is because a principle benefit to society from the innovation is that it lowers the total costs of production, which results in larger quantities being produced (and being sold for lower prices). The proposed DOJ intervention prevents the Red Cross or society from benefiting from the innovation in this way.

Notice in Figures 2 and 3 that there is a precipitous drop in relative consumer surplus at $c = 9/17$. This is due to consumers actually benefiting when the Red Cross engages in limit pricing as it does so by "over-selling" in the market for red blood cells and driving price down, which is clearly good for consumers. Limit pricing allows the Red Cross to extract more rents in the market for plasma, but consumers gain in the market for red blood cells as limit pricing is associated with a price for red blood cells equaling marginal cost, c.

Figure 2. Consumer Surplus under a DOJ Intervention relative to Consumer Surplus under the Innovation (α = 1).

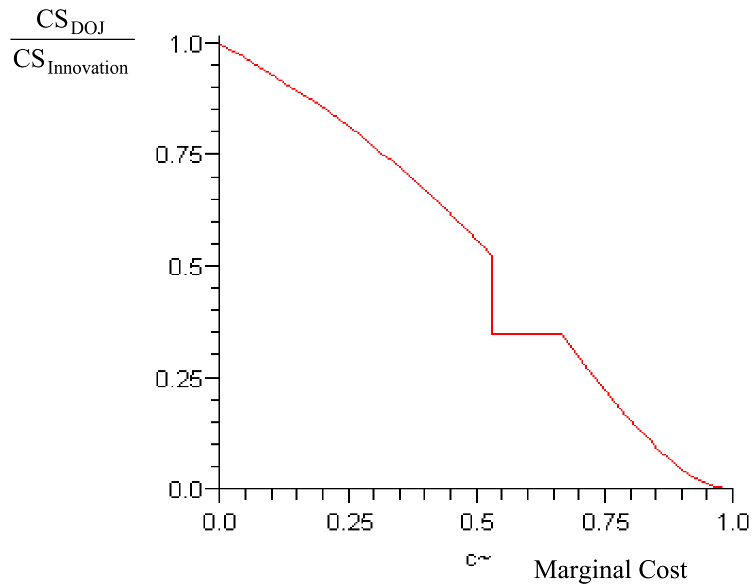
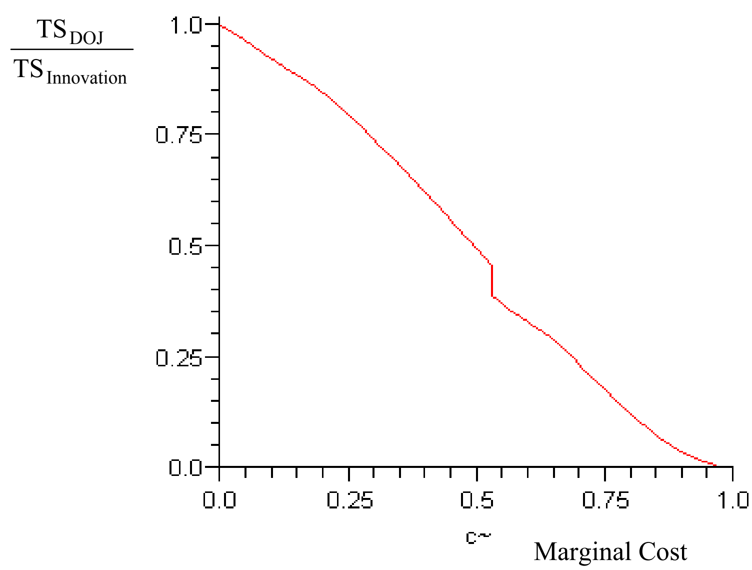


Figure 3. Total Surplus under a DOJ Intervention relative to Total Surplus under the Innovation (α = 1).



6. CONCLUSION

Economists have developed a significant literature concerning whether a monopolist can gain additional rents by leveraging its monopoly power to foreclose competition in a second, complementary market through tying the sale of its monopoly commodity to the sale of the commodity in the second market.[7] The Chicago School's refutation of leveraging, the "one monopoly rent theorem," may be traced to Director and Levi (1956). Director and Levi provided a simple proof establishing that leveraging cannot generate additional monopoly profits. This claim, however, has been challenged recently. Kaplow (1985) identified several heroic assumptions necessary to support the leverage hypothesis, including the reliance on a static framework and the assumption of perfect markets. Choi (1996, 2004) moved away from a static framework to highlight the application of leverage through the interaction of tying and R&D incentives. Whinston (1990) relaxed the perfect market assumption (allowing for increasing returns) to demonstrate that leveraging through tying may be profitable when a monopolist can alter the structure of the second market. Nalebuff (2004) established that Director and Levi's result depends on the consumption of the goods in fixed proportions and once this assumption is replaced with consumption in variable proportions, monopoly power can be extended. Brennan and Kimmel (1986) also departed from the standard market assumptions in an attempt to show that a monopolist may leverage more rents by tying to jointly produced commodities.

We have provided an exercise designed to help students think through the implications of possible leveraging in a non-dynamic setting. Following the work of Brooks and Lybecker (2007), the analysis in this paper is motivated with an example from the market for blood and blood products, and focuses on the monopolization of goods tied at the point of production; in particular, the joint production of SD plasma and red blood cells. Depending on the parameter values, the firm that benefits from joint production may act as a dual monopolist, engage in limit pricing, or compete with a second firm. Specifically, this exercise examines whether, and under what conditions, a monopolist over one jointly produced good would seek to extend the monopoly to the other jointly produced good. We also examined issues regarding efficiency, and have set the stage for relaxing the assumption of identical markets.

In terms of the case study discussed throughout the paper, an argument can be made that the US Department of Justice should never have worried too much about the potential for the Red Cross to leverage its monopoly in the market for SD plasma to the market for red blood cells. This conclusion rests primarily

[7] For a discussion of the history of leverage theory and a review of the literature, see Whinston (1990) and Posner and Easterbrook (1981).

on the fact that the market for red blood cells is substantially larger than the market for plasma, which almost certainly precludes the Red Cross from "unfairly" benefiting from a joint production technology as the Red Cross would never find it optimal to "over produce" plasma simply to garner a cost advantage in the production of red blood cells.

REFERENCES

Brennan, T.J. and Kimmel, S. (1986), "Joint Production and Monopoly Extension through Tying," *Southern Economic Journal* 53(2), 490-501.

Brooks, R.R.W. and Lybecker, K.M. (2007), "Monopolizing Blood: Joint Production, Innovation and Leveraging Monopoly Power," working paper.

Choi, J.P. (1996), "Preemptive R&D, Rent Dissipation and the 'Leverage Theory'," *The Quarterly Journal of Economics* 111(4), 1153-1181.

Choi, J.P. (2004), "Tying and Innovation: A Dynamic Analysis of Tying Arrangements," *Economic Journal*, 114 (492), 83-101.

Director, A. and Levi, E. (1956), "Law and the Future: Trade Regulation," *Northwestern Law Review* 51, 281-296.

Kaplow, L. (1985), "Extension of Monopoly Power through Leverage," *Columbia Law Review* 85, 515-556.

Nalebuff, B.J. (2004), "Bundling as a Way to Leverage Monopoly," Yale SOM Working Paper No.ES-36. Available at SSRN: http://ssrn.com/abstract=586648.

Posner, R.A. and Easterbrook F.H. (1981), *Antitrust: Cases, Economic Notes and Other Materials*, West Publishing Company, St. Paul.

Whinston, M.D. (1990), "Tying, Foreclosure, and Exclusion," *The American Economic Review* 80(4), 837-859.