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CONTENT PROTECTION AND OLIGOPOLISTIC INTERACTIONS

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ABSTRACT

In oligopolistic situations content protection can have unexpected effects as it changes the nature of interactions between input suppliers. With a duopoly, it does so in a manner that makes the foreign firm wish to match price increases and decreases of the domestic firm. Domestic input suppliers can therefore lose from such policies, even when set at free trade levels. The relation between input demands, the form of protection, and the degree of substitution between inputs is shown to define the effects of content protection and to provide the basis for understanding who might lobby for protection in different environments.

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SECTION 1

INTRODUCTION

In this paper we analyze the effects of content protection schemes in an oligopolistic setting. Although much work has been done on such schemes, it has been confined to the polar cases of competition and monopoly. Content protection has qualitatively different effects in oligopolistic markets because it alters the nature of interactions between firms. In contrast to the results derived under competition and monopoly, we show that under certain conditions content protection, even when set at free trade levels, must lower the profits of domestic input supplies. We relate these conditions to the form of the protection scheme, and characteristics of the market on the demand and supply side.

The point that protection schemes act differently in different market structures can be made more clearly by identifying three effects of any restriction in oligopolistic markets. In a competitive framework, any form of protection works by altering the market demand and/or supply functions wherever the constraint is binding. If the constraint is set so that it is just binding at the free trade levels, it will not alter the demand and/or supply functions at equilibrium and so the free trade equilibrium must remain an equilibrium.[1] In other words, in competitive markets, restrictions affect equilibrium only by being restrictive. We call this the "C" effect.

In the case of domestic monopoly and foreign competition, even restrictions which would not have produced any effect under competitive conditions have significant effects. These arise because such restrictions alter demand or/and supply conditions at points aside from the unconstrained equilibrium point. Hence, they can affect the monopolists' choice. In this manner, restrictions can have significant effects by their sheer presence. This point was made in Bhagwati (1965). We call this the "M" effect.

In an oligopoly model, not only does the effect present in the competitive and monopoly models exist, but because each agent is affected in the manner the monopolist was in the previous paragraph, the actions of all agents can change. As the outcome depends on all agents interacting, an additional effect arises. This point was made in Krishna (1984), and we call this the "I" effect. Notice that in the oligopoly case, both "C" and "M" effects also exist. Although the "M" effects of protection at free trade levels cannot but benefit domestic producers, the "I" effects can be harmful if they work against the "M" effects. "C" effects are local effects while "M" and "I" effects are global effects like those of a change in regime. Therefore, they are likely to be very important. We analyze content protection schemes which are just binding at the free trade levels. The "C" effect is therefore eliminated, which allows us to focus on the "M" and "I" effects.

Intermediate good markets provide a natural product differentiation through the production function for the final good. They also provide simple examples of products being complementary or substitutable in demand, i.e., of demand for an input falling or rising in response to an increase in the other inputs price, as well as of "unusual" slopes of best response functions. We do not restrict ourselves for this reason to considering only substitute goods or particularly sloped best response functions.

We consider content protection schemes specified in physical terms as well as in value-added terms. We find that the effect of content protection schemes depends upon three factors, the first being the form of the scheme, namely whether it is specified in physical or value added terms. The second is the degree of substitution between inputs, namely, whether the elasticity of substitution exceeds one or not. The third is whether an input's demand rises or falls when the other input's price rises--i.e., whether inputs are substitutes or complements in demand.

If content protection is specified in physical terms, we show that equilibrium prices tend to rise, but that the domestic firm loses from protection if the inputs are complements, but gains if they are substitutes. If content protection is specified in value added terms, the results are identical to those of physical content protection as long as the elasticity of substitution exceeds one. They are reversed if it is less than one, so that price tend to fall, and the domestic firm gains from protection if the inputs are complements, and loses if they are substitutes.

In Section 2 we set up the model which is used in Section 3 to study physical content protection, and in Section 4 to study value added content protection. In Section 5 we disucss the effects of physical content protection when there is an additional factor, such as domestic labor, which is competitively supplied. Finally, we analyze the incentives for lobbying efforts on the part of labor and producers in the context of this model. We offer a few comments on our results in the concluding section.

SECTION 2

The Model

In this section we examine the factors which affect the demand for intermediate inputs in imperfectly competitive markets. We assume that there are two intermediate inputs, which combine to produce the output of the final good. One of the inputs is produced by the home country, while the other is produced by the foreign country. Both inputs are produced at a given constant marginal cost. We assume that the technology for the production of the final good is that of constant returns to scale, and that the final product is competitively supplied by domestic firms. Throughout we assume that the demand for the final product is given by a well behaved downward sloping demand function. We will denote foreign variables with "*"s. Thus, w and $w*$ are the prices of the intermediate inputs, and $z(w,w*)$ and $z*(w,w*)$ are their demands. r and $r*$ are the constant marginal costs of producing the inputs. $D(p)$ gives the demand for the final product as a function of its own price, p.

As we assume constant returns to scale in the production of the final good, the unit cost function for the production of the final good is independent of the level of output and depends only on input prices. It is also homogeneous of degree one in them. Unit cost is denoted by $c(w,w*)$ and $w/w* = \omega$. Of course, $c(w,w*)$ has the usual properties, namely, $c_w(w,w*) = a(\omega)$ and $c_{w*}(w,w*) = a*(\omega)$, where a and $a*$ are the unit input coefficients. As usual, subscripts on functions denote partial derivatives with respect to the subscripted variable.

Demand for z consists of the product of the amount of z needed to produce one unit of the final product, $a(\omega)$, and the total amount of the final product produced, $D(p)$. Due to the assumption of perfect competition in the final product market we know that $p = c(w,w*)$. Hence:

$$(1) \qquad z(w,w*) = a(\omega)D(c(w,w*)) \quad \text{and}$$

$$(2) \qquad z*(w,w*) = a*(\omega)D(c(w,w*)).$$

Note that demand for inputs is a <u>derived</u> demand. Input prices affect demand through two channels: via the input coefficients and via demand for the final product, which depends upon unit production costs. Profit functions for domestic and foreign input suppliers are therefore given by:

$$(3) \qquad \pi(w,w*) = (w-r)z(w,w*) \quad \text{and}$$

$$(4) \qquad \pi*(w,w*) = (w*-r*)z*(w,w*).$$

$B(w*)$ and $B*(w)$ are the best response functions of the domestic and foreign firms, to a given price charged by their competitor. They are defined by the first order conditions:

$$(5) \qquad \pi_w(B(w*),w*) = 0 \quad \text{and}$$

$$(6) \qquad \pi*_{w*}(w,B*(w)) = 0,$$

respectively. Nash equilibrium is defined by both (5) and (6) holding, so that each price charged is a best response to the other.

It is often thought that if competition between firms involves choosing prices and the products are substitutes for one another, then best response functions must be upward sloping. One exception to this can be found in Bulow, Geanakoplos and Klemperer (1985) who show that there is little reason to associate a particular slope of the best response functions with a particular strategic variable. It is also usually assumed that products are substitutes in demand, but the market for intermediate goods can be shown to provide natural examples of complementary goods and unusual slopes of the best response functions.[2]

In the next sections we consider the effects of content protection and show that this depends on the form of protection, whether inputs are complements or substitutes, and whether $\sigma \gtrless 1$.

Section 3

3.1 Content Protection

Content protection policies require that a given proportion of domestic value added, or a given proportion of domestic components be embodied in the final product. The policy is enforced by setting penalties for non-compliance. These often take the form of tariffs on imported intermediate goods, and/or the removal of tariffs on imports of the final good. Throughout we assume that the penalties are sufficient to deter non-compliance. Therefore, we do not need to specify the penalties themselves. We will first discuss content protection policies in general. Then we will consider the effects of a content protection scheme specified in physical terms. Lastly we will consider value added schemes, as they are more complicated.

Content protection schemes are means often used by developing countries attempting to build a manufacturing base, and by developed countries to prevent the erosion of such a base in industries threatened by foreign competition. Taiwan has used such policies in the television and refrigerator industries, while the U.S. has used them to revitalize its ship building industry. Canada used them to protect her auto industry before the Auto Pact.[3] Among the more pernicious of such schemes seem to be the content protection schemes that have been in existence in Australia for the auto industry for almost 25 years. These schemes have led to a proliferation of models unwarranted by technological conditions and market size and a cost almost double that of imports. For a very amusing and informative history--see Gregory and Ho (1985). More recently, proposals have been made to institute domestic content requirements on the automobile industry in the U.S.

Content protection policies have been previously analyzed in the literature, at both a theoretical and empirical level. The works of Wonnacott and Wonnacott (1967), Munk (1969), Johnson (1971), Corden (1971), McCulloch and Johnson (1973), Grossman (1981) and Mussa (1984) are in particular worth mentioning. McCulloch and Johnson pointed out that a content protection scheme is basically a proportionally distributed quota as the ability to import foreign inputs depends on the use of domestic inputs. Content protection has been favorably compared to a tariff in Mussa (1984). The argument given there is that while content protection distorts the input mix, thereby raising costs, costs rise less than under a tariff that leads to the same input mix. This is because foreign input prices do not rise in the former case. Mussa (1984) also analyzes the implications for technological progress of such schemes. Grossman (1981) points out, among other things, that a content protection scheme which requires a given proportion of value added to be domestic, could actually reduce domestic value added in some cases if the importable and domestic inputs were "complementary".[4]

None of the existing work, to our knowledge, analyzes the effects of such schemes in oligopolistic markets where the results are very different. Oligopolistic markets <u>differ</u> from perfectly competitive markets as a content protection scheme, even one set <u>at</u> the free trade levels, can have a significant impact. In this they are similar to instances where a restriction creates a monopoly, and hence has an effect by its very existence. An analysis of oligopolistic markets <u>differs</u> from that of a monopoly, as more than one firm behaves strategically, and content protection affects the behavior of <u>all</u> firms. Hence, the equilibrium, which depends on the strategic interactions of <u>all</u> firms, may change in ways which are <u>not</u> possible with a domestic monopoly and foreign competition. For example, content protection at the free trade level cannot reduce the domestic input producer's profits if he is a monopolist and the foreign input is competitively supplied, as argued by Mussa (1984). This is because he always has the choice of charging the free trade price. However, this argument is not sufficient to ensure that profits of the domestic producer must rise when the foreign input is also supplied under imperfectly competitive conditions. This is because the <u>equilibrium</u> may involve the foreign firm charging a different price from that charged under free trade.[5]

3.2 Content Protection and the Profit Function.

Consider the effect of a content protection scheme which requires that the ratio of physical inputs, $\frac{a}{a*}$, used in producing a unit of output be at least as great as $\bar{\alpha}$.[6] Physical content protection schemes might be possible to implement for goods like yarn where different fibers are combined to produce yarn. We use Diagram 1 to illustrate our arguments. In it, $F(z,z*) = 1$ traces out the efficient combinations of z and $z*$ needed to make a unit of final output. The combinations of inputs which both make a unit of output and give $\frac{a}{a*} \geq \bar{\alpha}$ is given by the shaded area in Diagram 1. If ω exceeds $\bar{\omega}$ in Diagram 1, the content protection scheme can be seen to be binding. and $a(\bar{w})$, $a^*(\bar{w})$ are the unit input coefficients. If ω is less than $\bar{\omega}$, it is not binding,[7] and unit input choices are the unconstrained ones. The ratio $\frac{a}{a*}(\omega)$ in the absence of any protection is depicted in Diagram 3 by a downward sloping curve such as BB' for obvious reasons. The constraint makes this ratio into the line BED.

We will define the profit function in the presence of a scheme as a composite of the unconstrained profit function, $\pi(w, w^*)$ and the profit function on the assumption the constraint is binding, $\bar{\pi}(w, w^*)$. On the <u>assumption</u> the constraint is binding, minimized unit costs of production are given by $\bar{c}(w,w*) = w'a(\bar{\omega}) + w*a*(\bar{\omega})$. $\bar{c}(w,w*)$ exceeds $c(w,w*)$, except when $\omega = \bar{\omega}$, the point at which the constraint just bites, where it is equal to $c(w,w*)$.

Let $\bar{\pi}(w,w*)$ and $\bar{\pi}*(w,w*)$ denote the profit functions for the home and foreign firms respectively <u>on the assumption</u> that the scheme is binding so that:

(7) $\bar{\pi}(w,w*) = (w-r)a(\bar{\omega})D(a(\bar{\omega})w + a*(\bar{\omega})w*)$ and

(8) $\bar{\pi}*(w,w*) = (w*-r*)a*(\bar{\omega})D(a(\bar{\omega})w + a*(\bar{\omega})w*)$.

Let $\hat{\pi}(w,w*)$ and $\hat{\pi}*(w,w*)$ be the profit functions of the domestic and foreign firm when the content protection scheme is imposed. The scheme is binding if $\omega \geq \bar{\omega}$ and is not binding if $\omega < \bar{\omega}$. This allows us to write $\hat{\pi}$ and $\hat{\pi}*$ as follows:

$$(9) \quad \hat{\pi}(w,w*) = \bar{\pi}(w,w*) \quad \text{if} \quad w \geq \bar{\omega}w*$$
$$= \pi(w,w*) \quad \text{if} \quad w \leq \bar{\omega}w*.$$
$$(10) \quad \hat{\pi}*(w,w*) = \pi*(w,w*) \quad \text{if} \quad w* \geq w/\bar{\omega}$$
$$= \bar{\pi}*(w,w*) \quad \text{if} \quad w* \leq w/\bar{\omega}.$$

Notice that $\hat{\pi}$ and $\hat{\pi}*$ are continuous, as $a(\bar{\omega}) = a(\omega)$ for $\omega = \bar{\omega}$.

Having defined the profit functions, $\hat{\pi}$ and $\hat{\pi}*$, we need to examine their properties. Throughout this section, we will assume that π and $\bar{\pi}$, $\pi*$ and $\bar{\pi}*$, are concave functions in their own price, given any price set by the other. The properties of $\hat{\pi}$ and $\hat{\pi}*$ cannot be assumed, but must be derived from their definition in terms of their unbarred and barred components.

Using Diagram 1, it is easy to verify that the slope of $\bar{\pi}$, $\bar{\pi}_w$ <u>must</u> exceed π_w, when evaluated at points where the constraint just binds. This is because $\bar{\pi}_w$ and π_w differ at such points only because $a(\omega)$ falls as w rises while $a(\bar{\omega})$ is unchanged.[8] There are, therefore, only three possible relationships between the slopes of π and $\bar{\pi}$ at such points. Either:

$\bar{\pi}_w > \pi_w \geq 0$ or

$\bar{\pi}_w > 0 \geq \pi_w$ or

$0 \geq \bar{\pi}_w > \pi_w$.

These three cases are denoted as case a, b, and c, respectively. Similar arguments show that $\bar{\pi}*_{w*}$ must exceed $\pi*_{w*}$ as well, and an analogous three cases, a^*, b^*, c^*, to the ones above are the only ones possible. These possible shapes of $\hat{\pi}$, $\hat{\pi}^*$ are illustrated in Diagram 4. Also, due to the definitions of $\hat{\pi}$ and $\hat{\pi}*$, it is easy to see that $\hat{\pi}^*$ must be concave if $\pi*$ and $\bar{\pi}^*$ are concave.[9] It is easy to verify that $\hat{\pi}$ is not concave. An implication of the concavity of

$\hat{\pi}^*$, and the nonconcavity of $\hat{\pi}$ is that the best response function of the foreign firm must be continuous, while that of the domestic firm need not be. These characteristics of $\hat{\pi}$ and $\hat{\pi}^*$ help us to characterize the form of the best responses of each firm in the presence of a content protection scheme. We turn to this task in what follows.

3.3 Content Protection and Best Responses

Under a content protection scheme $\hat{\pi}$ is either π or $\bar{\pi}$ and the switch between them is made along $\frac{w}{w*} = \bar{\omega}$ where they are equal to one another. This switching between profit functions makes characterization of the best response functions slightly tricky. First we will derive the best response associated with $\hat{\pi}(w,w*)$, which we denote by $\hat{B}(w*)$. Define $\bar{B}(w*)$ as the best response function associated with $\bar{\pi}(w,w*)$. $B(w*)$ is, as before, the best response function associated with $\pi(w,w*)$. $\hat{B}*(w)$, $\bar{B}*(w)$ and $B*(w)$ are defined analogously. $B,B*$ and $\bar{B},\bar{B}*$ are depicted in Diagram 5.[10]

As $\hat{\pi}(w,w*)$ is made up of segments of $\bar{\pi}$ and π, and $\hat{\pi}$ switches from π to $\bar{\pi}$ at $\omega = \bar{\omega}$, $\hat{B}$ must be either B or $\bar{B}$ or lie along the kink at $\omega = \bar{\omega}$. However, for $\hat{B}$ to lie along the kink, π must be upward sloping and $\bar{\pi}$ must be downward sloping at the kink. This possibility has been ruled out. Therefore, $\hat{B}(w*)$ is either $\bar{B}(w*)$ or $B(w*)$. Moreover, Lemma 1 which follows characterizes the conditions when it is one or the other.

<u>Lemma 1</u> Take a given value of $w*$ and let π_w, $\bar{\pi}_w$ be evaluated at $w = \bar{\omega}w*$.

If $\quad \bar{\pi}_w(w,w*) > \pi_w(w,w*) \geq 0,$

then $\quad \hat{B}(w*) = \bar{B}(w*).$

If $\quad \bar{\pi}_w(w,w*) > 0 > \pi_w(w,w*),$

then
$$\begin{aligned} \pi(w,w*) &= B(w*) && \text{if} \quad \bar{\pi}(\bar{B}(w*),w*) < \pi(B(w*),w*) \\ &= \bar{B}(w*) && \text{if} \quad \bar{\pi}(\bar{B}(w*),w*) > \pi(B(w*),w*) \\ &= [\bar{B}(w*),B(w*)] && \text{if} \quad \bar{\pi}(\bar{B}(w*),w*) = \pi(B(w*),w*). \end{aligned}$$

If $\quad 0 \geq \bar{\pi}_w(w,w*) > \pi_w(w,w*),$

then $\quad \hat{B}(w*) = B(w*).$

<u>Proof</u>

Lemma 1 is obvious once $\hat{\pi}$ is drawn as in Diagram 4 . $\square$

Lemma 1 completely characterizes the best response function, $\hat{B}(w*)$.[11] One possible shape of $\hat{B}(w*)$ is depicted in Diagram 5.

In an analogous fashion to our argument about $\hat{B}(w*)$, we can show that $\hat{B}*(w)$ is either $B*(w)$ or $\bar{B}*(w)$, or that it lies along the line $\omega = \bar{\omega}$. Since $\hat{\pi}*(w,w*)$ is known to be concave in $w*$ for a given w, the best response function $\hat{B}*(w)$ must be continuous. Moreover, $\hat{B}*(w*)$ can be completely characterized as follows in Lemma 2.

Lemma 2: Let w be given, and let the following derivatives be evaluated at $w* = w/\bar{\omega}$.

If $\quad \bar{\pi}*_{w*}(w,w*) > \pi*_{w*}(w,w*) \geq 0$,

then $\quad \hat{B}*(w) = B*(w)$.

If $\quad \bar{\pi}*_{w*}(w,w*) > 0 > \pi*_{w*}(w,w*)$,

then $\quad \hat{B}*(w) = \frac{w}{\bar{\omega}}$.

If $\quad 0 \geq \bar{\pi}*_{w*}(w,w*) > \pi*_{w*}(w,w*)$,

then $\quad \hat{B}*(w) = \bar{B}*(w)$.

Proof: Follows from drawing $\hat{\pi}*$ as in Diagram 4. ∎

$\hat{B}*$ is also portrayed in Diagram 5.

3.4 Equilibrium with Content Protection

In order to determine the effects of content protection, we need to characterize the equilibrium. We are now in a position to do so. We will consider the effect of restrictions set at the free trade levels. Since we are interested in the effect of a content protection scheme on interactions between firms, we will assume that in the absence of any protection there are no asymmetries between the firms and that a unique stable pure strategy equilibrium exists when $B, B*$ or $\bar{B}, \bar{B}*$ are the best response functions. We have therefore assumed that $\bar{B}$ and $\bar{B}*$ intersect only once. Since there are no asymmetries between the firms, and since the restriction is set at free trade levels, $\bar{B}$ and $\bar{B}*$ must intersect along the $\bar{\omega}$ line.

The stability of the free trade equilibrium ensures that $B(w*)$ lies above the $\bar{\omega}$ line, when $w* < w*_N$, and below it when $w* > w*_N$. Therefore, π_w must be positive along the $\bar{\omega}$ line if $w* < w*_N$. Hence $\bar{\pi}_w$ must also be positive here, and $\bar{B}(w*)$ must lie above the $\bar{\omega}$ line when $w* \leq w*_N$. By arguing analogously about $\bar{B}(w)$ and $B*(w)$, it becomes obvious that the intersection of $\bar{B}(w*)$ and $\bar{B}*(w)$ must occur to the right of the free trade equilibrium at a point such as $(w_A, w*_A)$ in Diagram 5. We also know, by our assumptions of symmetry, stability and single intersection of $\bar{B}$ and $\bar{B}*$, that $\bar{B}(w*)$ must lie above the $\bar{\omega}$ line when $w* < w_A*$, and below it when $w* > w_A*$.

Now, if $w* \leq w*_N$, Lemma 1 ensures that $\hat{B}(w*) = \bar{B}(w*)$ since both $\bar{\pi}_w$ and π_w are positive along the $\bar{\omega}$ line. If $w_A^* \leq w*$, Lemma 1 ensures that $\hat{B}(w*) = B(w*)$, since both $\bar{\pi}_w$ and π_w are negative along the $\bar{\omega}$ line. If $w*_N < w* < w*_A$, then $\hat{B}(w*)$ could be either $B(w*)$ or $\bar{B}(w*)$. This is because $\bar{\pi}_w(w,w*) > 0 > \pi_w(w,w*)$ along the $\bar{\omega}$ line in this event, and the results of Lemma 1 apply once more. One possible shape of $\hat{B}(w*)$ is illustrated in Diagram 2. $\hat{B}(w*)$ may, of course, jump more than once, but it can only jump for values of $w*$ between $w*_N$ and $w*_A$.

Now we turn to the shape of $\hat{B}*(w)$. If $w < w_N$, $B*(w)$ must lie below the $\bar{\omega}$ line due to the stability assumption we made. Hence, $\pi*_{w*}$ along the $\bar{\omega}$ line must be positive, and therefore, so must $\bar{\pi}*_{w*}$. By Lemma 2, $\hat{B}*(w)$ must equal $B*(w)$. If $w > w_A$, then both $\bar{\pi}*_{w*}$ and $\pi*_{w*}$ are negative along the $\bar{\omega}$ line, so that $\hat{B}*(w)$ must equal $\bar{B}*(w)$. If $w_A \geq w \geq w_N$, then $\bar{\pi}*_{w*}$ is positive, while $\pi*_{w*}$ is negative, so $\hat{B}*(w)$ must lie along the $\bar{\omega}$ line. $\hat{B}*(w)$ is drawn in Diagram 5. The assumption of symmetry and a unique intersection of $\bar{B}(w*)$ and $\bar{B}*(w)$ also ensures that $\hat{B}(w*)$ and $\hat{B}*(w)$ do not intersect, so that there is no pure strategy equilibrium.

Notice that we already know a fair amount about the mixed strategy equilibrium. Glicksberg's theorem ensures that it exist.[12] We will verify that it does exist later on as well. Since $\hat{\pi}*$ is concave in $w*$, the equilibrium must involve the foreign firm charging a single price, and <u>not</u> randomizing. Since no pure strategy equilibrium exists, it must involve the domestic firm randomizing over the prices. To do so, it must be indifferent between them, so that both prices must both lie on the same iso-profit contour. This is a point where the reaction function jumps. Recall that $\hat{B}(w*)$ can only jump when $w*$ lies between $w*_N$ and $w*_A$.

Diagram 5 illustrates an equilibrium under the content protection scheme. The domestic producer randomizes between the two prices w_1 and w_2, whereas the foreign producer sets the price $w*_1$. Although the domestic producer's best response function has only one jump here, there is a possibility that it has more jumps. However, since jumps can only occur when $w*_N < w* < w*_A$, the price charged by the foreign firm in any equilibrium must rise due to the content protection scheme. Also, if the products are complements, the domestic firm's profits must fall since the profits along $B(w*)$ in this region are lower than $\hat{\pi}^N$, as depicted in Diagram 5. If the products are substitutes, domestic profits must rise. The domestic firm's average price may rise or fall, as can the foreign firm's profits. The proportion of value added domestically, or domestic input use could rise or fall as well.

Our arguments have allowed us to show that domestic profits rise or fall due to a physical content protection scheme, set at the free trade level, according to whether the products were substitutes or complements. In doing so, we used the fact that an equilibrium in mixed strategies existed. Alternatively, it can be seen to exist in Diagram 5 by noting that we only need to show that there exists a randomization between w_1 and w_2 available to the home firm, which makes the foreign firm wish to charge $w*_1$, which is easy. Notice that $\hat{B}*(w_2) < w_1*$ and $\hat{B}*(w_1) > w*_1$, and $\hat{\pi}*(w,w*)$ is concave in $w*$. Hence, $\hat{\pi}*_{w*}(w_1,w*_1) > 0$ while $\hat{\pi}*_{w*}(w_2,w*_1) < 0$. Since it is easy to find a convex combination of a positive and negative number that gives zero, we have shown that a feasible randomization exists for the domestic firm, such that the foreign firm wishes to charge w_1*.

Theorem 1 states our main results for this section:

Theorem 1: The effect of a physical content protection scheme, set at the free trade level, is to raise domestic profits if the products are substitutes, but to lower them if they are complements. Foreign prices always rise, although average domestic prices need not always rise. The proportion of value added and total domestic input use could, likewise, rise or fall. $\square$

This result makes some intuitive sense when the effect of content protection is decomposed into the "C", "M", and "I" effects previously mentioned. If the restriction is set at the free trade level, there are by definition no "C" effects. Irrespective of whether products are substitutes or complements, the home firm wants to raise its price, since content protection makes the demand function facing it less elastic for higher prices, although it doesn't alter demand at the free trade equilibrium.

Hence the "M" effect for the domestic firm causes w to rise. This is represented by the movement from the free trade equilibrium to M in Diagram 5. Notice that profits cannot fall due to the "M" effect. The foreign firm, on the other hand, doesn't want to change its price from w^*_N, and no "M" effect operates on it.

The "I" effect consists of the movement from the M point to the new equilibrium. Since the restriction makes the foreign firm respond to price increases by increasing its price, the interaction effect tends to raise w^*, and can raise or lower w from the M position.[13] Although the "M" effect raises the home firm's profits, the "I" effect towards higher foreign prices tends to lower them if the products are complements, but raise them if the products are substitutes. In the latter case both M and I effects work in the same direction and domestic profits rise. In the former case, they work in opposite directions. Moreover, the "I" effect dominates the "M" effect and domestic profits fall. The effect on foreign profits is less clearcut, and it is possible for foreign profits to rise or fall.

So far, we have restricted ourselves to an analysis of physical content protection. In the next section, we build on this in our analysis of value added content protection.

SECTION 4

4.1 Value Added Restrictions

A value added constraint requires that $\frac{wa}{wa+w*a*} \geq \bar{\alpha}$ or equivalently, that $\omega\frac{a}{a*} \geq \frac{\bar{\alpha}}{1-\bar{\alpha}}$. The unit input choice under the value added constraint is complicated by the fact that the feasible set of inputs itself depends on the value of ω. The set of feasible inputs consists of the combinations of inputs which both meet the restriction that $\frac{a}{a*}$ lies above $\frac{\bar{\alpha}}{1-\alpha}\frac{1}{\omega}$, and which produce at least a unit of output. This set is depicted in Diagram 2 by the shaded region. It is easy to see from this diagram that if the value added constraint is binding, the cost minimizing input coefficients are given by the $\frac{a}{a*}$ that lie on the unit isoquant and just meet the value added constraint. Denote these inputs by $\bar{a}$ (ω, α) and $\bar{a}^*(\omega, \alpha)$. If the constraint is not binding, the choice of inputs is the unconstrained one.

The only question that remains then, is when the constraint is binding. As the value added restriction is equivalent to the requirement that $\omega\frac{a}{a*} \geq \frac{\bar{\alpha}}{1-\alpha}$, the restriction is binding if $\omega\frac{a(\omega)}{a*(\omega)}$ falls short of $\frac{\bar{\alpha}}{1-\alpha}$, and not binding if it exceeds $\frac{\bar{\alpha}}{1-\alpha}$. Differentiating $\omega\frac{a(\omega)}{a*(\omega)}$ shows that this increases with ω if $\sigma < 1$, but decreases with ω if $\sigma > 1$ since σ measures the responsiveness of $\frac{a(\omega)}{a*(\omega)}$ to changes in ω. We will assume that $\frac{a(\omega)}{a*(\omega)}\omega$ is monotonic, and define $\bar{\omega}$ to be where it equals $\frac{\bar{\alpha}}{1-\alpha}$. The curve AA' in Diagram 3 gives the combinations of ω and $\frac{a}{a*}$ which give a constant product of $\frac{\bar{\alpha}}{1-\alpha}$. If $\sigma > 1$, then the unit input ratio $\frac{a(\omega)}{a*(\omega)}$ will be given by a curve like BB', and one like CC', if $\sigma < 1$. $\bar{\omega}$, the point where the constraint just binds, is given by the intersection of AA' with BB' or CC'. If $\sigma < 1$, and $\omega > \bar{\omega}$, the unconstrained choice of $\frac{a}{a*}$, $\frac{a(\omega)}{a*(\omega)}$ is larger than that needed to meet the value added constraint and the constraint does not bind. If $\omega < \bar{\omega}$, the unconstrained choice of $\frac{a}{a*}$, $\frac{a(\omega)}{a*(\omega)}$ is smaller than that required to meet the value added constraint and the constraint binds. Notice that this is the opposite of where the constraint binds for the physical restriction. Thus, the choice of $\frac{a}{a*}$ is given by the line CEA'. If on the other hand $\sigma > 1$ then the constraint bites for $\omega > \bar{\omega}$ and doesn't bite for $\omega < \bar{\omega}$. This is similar to the way a physical content protection scheme operates. The choice of $\frac{a}{a*}$ is therefore given by AEB' in this case.

The cost minimizing input coefficients, when the constraint is binding, are obviously $\bar{a}(\omega,\alpha)$ and $\bar{a}*(\omega,\alpha)$, of Diagram 2.[14] If the constraint is not binding, they can be seen to be the unconstrained unit input coefficients. We will define $\bar{c}(w,w*,\alpha)$ as the cost function, on the <u>assumption</u> that the constraint is binding, even when it really is not, so that the unit input coefficients are given by $\bar{a}(\omega,\alpha)$ and $\bar{a}^*(\omega,\alpha)$. Thus, $\bar{c}(w,w*,\alpha)$ equals $w\bar{a}(\omega,\alpha) + w*\bar{a}^*(\omega,\alpha)$, and lies strictly above $c(w,w*)$, except where $\omega = \bar{\omega}$, where it equals it. The slopes of c and $\bar{c}$ are therefore equal at all points where the constraint <u>just</u> binds.

Now we turn to the implications of these facts on the profit functions. As before, we will define $\bar{\pi}(w,w^*,\alpha)$ and $\bar{\pi}^*(w,w^*,\alpha)$ as the profit functions on the <u>assumption</u> that the value added constraint is binding, and $\hat{\pi}(w,w^*,\alpha)$ and $\hat{\pi}^*(w,w^*,\alpha)$ as the profit functions in the presence of the value added constraint which are composed of segments of $\bar{\pi}(w,w^*,\alpha)$ and $\pi(w,w^*)$ and $\pi^*(w,w^*)$ and $\bar{\pi}^*(w, w^*,\alpha)$ respectively. As usual:

$$\bar{\pi}(w,w^*,\alpha) = (w - r)\ D(\bar{c}(w,w^*,\alpha)) \text{ and}$$

$$\bar{\pi}^*(w,w^*,\alpha) = (w^* - r^*)\ D(\bar{c}(w,w^*,\alpha)).$$

Now compare $\bar{\pi}_w(w,w^*,\alpha)$ to $\pi_w(w,w^*,\alpha)$ at $w = \bar{\omega}w^*$. Since $\bar{c}_w(w,w^*,\alpha) = c_w(w,w^*) = a(\omega)$ and $\bar{c}(w,w^*,\alpha) = c(w,w^*)$ at such points, the only difference between $\bar{\pi}_w(w,w^*,\alpha)$ and $\pi_w(w,w^*,\alpha)$ arises because of a differential response of $\bar{a}(\omega,\alpha)$ and $a(\omega)$ to changes in w. If $\sigma > 1$, then the line AA' is steeper than BB', so $\bar{a}(\omega,\alpha)$ is less responsive to changes in w than $a(\omega)$ and although both fall as w rises, $a(\omega)$ falls by more. Thus, $\bar{\pi}_w(w, w^*,\alpha) > \pi_w(w,w^*)$ when evaluated at points where the constraint just binds. The constraint also only binds for values of w higher than $\bar{\omega}\omega^*$. The shape of $\hat{\pi}(w,w^*,\alpha)$, the profit function of the domestic firm in the presence of a value added constraint, is therefore just like that of $\hat{\pi}(w,w^*)$ in Section 3.

Similarly, an increase in w* lowers $\bar{a}^*(\omega,\alpha)$ by less than it lowers $a^*(\omega)$, and $\bar{\pi}^*_{w^*}(w,w^*,\alpha) > \pi^*_{w^*}(w,w^*)$ at points where the constraint just binds. The constraint also binds only for values of w* less than $w/\bar{\omega}$. The shape of $\hat{\pi}^*(w,w^*,\alpha)$ is therefore also like that of $\hat{\pi}^*(w,w^*)$ in Section 3. In Section 3, the effect of content protection basically followed from the shapes of $\hat{\pi}$ and $\hat{\pi}^*$. The same results therefore hold for value added protection schemes when $\sigma > 1$.

If $\sigma < 1$, then it can be seen from Diagram 3 that raising w, from the point when the constraint just binds, lowers $\bar{a}(\omega, \alpha)$ by <u>more</u> than it lowers $a(\omega)$. This implies that the input demand function under the <u>assumption</u> the constraint binds is locally <u>more</u> elastic than the unconstrained one.[15] Thus, at points where the constraint just binds, $\bar{\pi}_w(w,w^*,\alpha) < \pi_w(w,w^*)$. Moreover, the constraint becomes binding at <u>low</u> values of w, <u>not</u> high ones so that $\hat{\pi}(w,w^*,\alpha)$ <u>remains</u> nonconcave.

Similarly, raising w* lowers $\bar{a}^*(\omega,\alpha)$ more than it lowers $a^*(\omega)$. This means that $\bar{\pi}^*_{w^*}(w,w^*,\alpha)$ must be less than $\pi^*_{w^*}(w,w^*)$ at points where the constraint just binds. However, since the constraint is binding only for <u>high</u> values of w*, $\hat{\pi}(w,w^*,\alpha)$ must be concave in w* as before.

Due to these differences, Lemmas 1 and 2 need to be converted to Lemmas 1' and 2'. All derivatives are evaluated as points where the constraint just binds. The notation is abbreviated, but should be clear. As the arguments made in this section are so similar to those previously made, we will be terse in our presentation.

Lemma 1′

If $\quad \bar{\pi}_w < \pi_w \leq 0,$

then $\quad \hat{B} = \bar{B}.$

If $\quad \bar{\pi}_w < 0 < \pi_w,$

then $\quad \hat{B} = B \quad$ if $\pi(B, w*) > \bar{\pi}(\bar{B}, w*)$

$\hat{B} = \bar{B} \quad$ if $\pi(B, w*) < \bar{\pi}(\bar{B}, w*)$

$\hat{B} = [B, \bar{B}]$ if $\pi(B, w*) = \bar{\pi}(\bar{B}, w*).$

If $\quad 0 \leq \bar{\pi}_w < \pi_w,$

then $\quad \hat{B} = B. \quad \Pi$

Lemma 2′

If $\quad \bar{\pi}^*_{w*} < \pi^*_w \leq 0,$

then $\quad \hat{B}^* = B.$

If $\quad \bar{\pi}^*_{w*} < 0 < \pi^*_w,$

then $\quad \hat{B}^* = \frac{w}{\omega}.$

If $\quad 0 \leq \bar{\pi}^*_{w*} < \pi^*_w,$

then $\quad \hat{B}^* = \bar{B}. \quad \Pi$

Using Lemmas 1′ and 2′, one can show that the equilibrium must be similar to that in Section 3. The only differences are that $\bar{B}(w^*_N) < w_N$ and the jump in $\hat{B}$ occurs below w_N. Therefore, if the products are substitutes,[16] a value added scheme set at free trade levels lowers the equilibrium profits of the domestic firm. If the products are complements, domestic profits rise. The results of Section 3 are seen to be reversed when a value added scheme is considered and $\sigma < 1$. Notice also the tendency for prices to fall in equilibrium, as opposed to their tendency to rise when $\sigma > 1$. Diagram 6 illustrates the equilibrium when $\sigma < 1$.

When $\sigma < 1$, the "M" effect on the domestic producer causes him to <u>lower</u> his price. As the restriction gives the foreign producer an incentive to lower his price in response to a lower domestic price, foreign price falls. If the goods are complements this raises domestic profits. Since the "M" effects always raises profits, both "M" and "I" effects work in the same direction, and domestic profits rise. If the goods are substitutes, the "I" effect of lowering foreign prices and hence domestic profits, works against the "M" effect and in fact outweighs it so domestic profits fall. The effect on foreign profits is again less clear.

We summarize the main results in this section as Theorem 2.

<u>Theorem 2</u>

The effect of a value added content protection scheme, set at the free trade level, depends on whether the elasticity of substitution, σ, is more or less than one, as well as whether the products are substitutes or complements. If $\sigma > 1$ foreign prices rise,and if the products are substitutes, domestic profits rise, while if they are complements, domestic profits fall. If $\sigma < 1$, foreign prices fall, and if the products are substitutes, domestic profits fall, but they rise if the products are complements. As before, average domestic prices, foreign profits, and domestic input use could rise or fall. $\underline{\Pi}$

SECTION 5

Extensions and Behavioral Implications

In this section we extend our model to allow for the presence of an additional competitively supplied domestic input such as labor. Our purpose is twofold. First, to allow some insight into how the addition of another factor affects our earlier results. Second, to analyze the possible conflicts of interest that might arise between labor and producers, and how these differ from the case where the foreign input is competitvely supplied. We consider the effects of physical content protection.

The important factor to model is the possibility of substitution between the competitively supplied input and the two others. This is done by assuming that z and z^* produce a composite intermediate input x, so that $x = G(z, z^*)$. $c(w, w^*)$ is its price. x, and labor, L, together produce the final good, Y and $Y = F(G(z, z^*), L)$. Both x and the final good are produced according to a CES production function with elasticities of substitution of σ and $\tilde{\sigma}$ respectively. q denotes the price of labor, $b(q/c)$ and $f(q/c)$ denote the input requirements of L and x needed to make a unit of the final good when input prices of L and x are q and c. Define $T(q, c(w, w^*))$ to be the unit cost of production, which equals p, the price of the final good.
Of course,

$$T(q, c(w, w^*) = cf(q/c) + qb(q/c).$$

Thus:

$$\pi(w, w^*) = (w-r)\ a(\omega)f(q/c)\ D(T(q,c)) \text{ and}$$

$$\pi^*(w, w^*) = (w^*-r^*)a^*(\omega)f(q/c)D(T(q,c))\ .$$

Labor is completely supplied with elasticity λ. Hence,

$$\hat{L} = \lambda\hat{q}$$

where "^"'s denotes rates of change.

The derived demand for labor is given by:

$L = b(q/c)\ D(p)$. Hence,

$\hat{L} = -\eta_b(\hat{q} - \hat{c}) - \varepsilon\hat{P}$.

where $\eta_b = -\hat{b}/(\hat{q/c})$.

The effect on q, in equilibrium, of changes in c and p are apparent from equating demand and supply in the labor market.

Notice that due to competition in the market for the final good,

$$\hat{P} = \theta_L\hat{q} + (1-\theta_L)\hat{c},$$

where $\theta_L = bq/p$, the share of labor in the production of Y.

This lets us express the effect of changes in c on the <u>equilibrium</u> wage in the labor market as

$$\hat{q} = \left[(\eta_b - \varepsilon(1-\theta_L))/(\lambda+\eta_b+\varepsilon\theta_L)\right]\hat{c} \quad ,$$

which gives the equilibrium relationship between changes in q and c. For the CES parameterization this can be further reduced to[17]:

$$\hat{q} = \left[(\tilde{\sigma} - \varepsilon)/((\lambda+\tilde{\sigma}) + (\lambda+\varepsilon)\tilde{\Phi})\right] \quad \hat{c}, \text{ where } \tilde{\Phi} = (\tfrac{q}{c})^{1-\tilde{\sigma}} .$$

The effect of an increase in c on the equilibrium price of labor depends on the sign of $(\tilde{\sigma}-\varepsilon)$. This is because increases in c both <u>lower</u> the derived demand for labor by increasing the price of the final good, and raise it, by encouraging substitution towards labor. The strength of the two effects depends on ε and $\tilde{\sigma}$ respectively. Notice that since c depends on w and w^*, and q depends on c as shown above, profits depend on w and w^* directly, and indirectly through q and c.

Physical content protection, as before, changes the unit inputs used in production of x to $\bar{a}$ and $\bar{a}^*$ when the constraint is binding. It is also binding in the same region as previously. The key feature needed for the results of Section 3 to go through in spirit is that $\bar{\pi}_w > \pi_w$ at points where the constraint just binds. As before, the only difference between $\bar{\pi}_w$ and π_w is that a change in w changes a but not $\bar{a}$. Now since neither the responsiveness of π to q and c, nor the responsiveness of q to c and c to w is affected by this differential responsiveness of a and $\bar{a}$ to changes in w, this feature must carry over, and all the results in Section 3 go through when interpreted in terms of inputs being substitutes or complements in demand.

The only question remaining is what factors determine when the input demands are complements and when they are substitutes. The effects of w^* on π, π_{w*}, are decomposed into direct effects via w^*, and indirect effects via q and c, to give:

$$\pi_{w*} = \frac{\partial \pi}{\partial w*} + \frac{\partial \pi}{\partial c}\frac{\partial c}{\partial w*} + \frac{\partial \pi}{\partial q}\frac{\partial q}{\partial c}\frac{\partial c}{\alpha w*} .$$

Some tedious calculations for the case where G(.) and F(.) are CES production functions with elasticities of substitution of σ and $\tilde{\sigma}$ reveals that in this case the first two terms sum up to:

$$\frac{\pi a*}{c}\left[\{(\sigma-\varepsilon)+(\sigma-\tilde{\sigma})\tilde{\Phi}\}/(1+\tilde{\Phi}) \right]$$

where $\tilde{\Phi}$ equals $(\frac{q}{c})^{1-\tilde{\sigma}}$, and the third equals:

$$\frac{\pi a*}{c}\left[(\tilde{\sigma}-\varepsilon)^2/((\lambda-\tilde{\sigma}) + (\lambda+\varepsilon)\tilde{\Phi}) \right]\left[\tilde{\Phi}/1+\tilde{\Phi}\right].$$

The sum of the first two terms incorporates the effects of substitution possibilities between z and z^* and L and x on derived demands. An increase in w^* now causes an additional effect - given by the presence of $(\sigma - \tilde{\sigma})$. Not only does it raise π by causing substitution towards z from z^*, but it lowers π by causing substition away from x and hence z. The third term captures the effects of profits of an increase in w^* due to the induced changes in the equilibrium wage in the labor market. It is always positive. This is because, as discussed earlier, an increase in c raises q only if $\tilde{\sigma}-\varepsilon > 0$, which is also the condition for π to rise with q. Thus, if $\tilde{\sigma} > \varepsilon$, an increase in c raises q which raises profits, while if $\tilde{\sigma} < \varepsilon$, an increase in c lowers q which raises profits! The inputs z and z^* can still be complements or substitutes, but the induced effects via q tend to make products complements, while the substitution possibilities between x and L could work in either direction. Physical content protection usually tends to raise costs both because it tends to raise w and w^*, and because it causes an input distortion. We will assume that it does raise costs and discuss the effects of content protection on the wage of labor and profits. The crucial parameters are σ, ε and $\tilde{\sigma}$. There are six possible cases shown in Figure 1. In Cases 1, 2, 5 and 6 the effect on π of content protection is ambiguous as the inputs z, z^* could be complements or substitutes in demand. However, both labor and producers would be in favor of protection in Case 4; while a conflict of interest is sure to arise in Case 3.

If the foreign supplier were competitive, and supplied at a given w^*, only "M" effects would exist so that π would always rise as would w and hence c. Therefore, labor would gain if $\tilde{\sigma}-\varepsilon > 0$, and lose if $\tilde{\sigma}-\varepsilon < 0$. The pattern of winners and losers is therefore different in the two market structures. A possible difference in the implications of the monopoly and oligopoly models arises in case 2 if ε is close to $\tilde{\sigma}$. The oligopoly model indicates that there will be no incentive to lobby for content protection in markets where the elasticity of final demand is relatively high compared to the elasticities of substitution, as it leads to cut throat competition and lowers the profits of the domestic input supplier and the wage of labor. The monopoly model indicates that input suppliers stand to gain from content protection.

Also notice that since $\frac{\tilde{\Phi}}{1+\Phi} = \theta_L$, the effect of the first two terms in the expression for π_{w*} equals:

$$\left[(\sigma-\varepsilon)(1-\theta_L) + (\sigma-\tilde{\sigma})\theta_L\right] (\pi a^*/c)$$

while the effect of the third term equals

$$((\tilde{\sigma}-\varepsilon)^2 \theta_L(1-\theta_L)) / ((\lambda+\tilde{\sigma})(1-\theta_L)+(\lambda+\varepsilon)\theta_L) .$$

Therefore the sign of π_{w*} is that of $\sigma - \tilde{\sigma}$ if θ_L is close enough to one, and that of $\sigma-\varepsilon$ if θ_L is close enough to zero. This is summarised in Table 1.

Value added content protection cannot be analyzed here as simply as in Section 4. Nor is there as much reason to expect an increase in c since w, w^* can fall. The full array of cases for value added content protection could be worked out, but it does not seem to add much to our understanding here, and we do not do so.

FIGURE 1

CASES	EFFECTS UNDER OLIGOPOLY			UNDER MONOPOLY
	$\theta_L \approx 1$	$0<\theta_L<1$	$\theta_L \approx 0$	
1) $\varepsilon>\sigma>\tilde{\sigma}$	$\pi\uparrow$ $q\downarrow$	$\pi?$ $q\downarrow$	$\pi\downarrow$ $q\downarrow$	$\pi\uparrow$ $q\downarrow$
2) $\varepsilon>\tilde{\sigma}>\sigma$	$\pi\downarrow$ $q\downarrow$	$\pi?$ $q\downarrow$	$\pi\downarrow$ $q\downarrow$	$\pi\uparrow$ $q\downarrow$
3) $\sigma>\varepsilon>\tilde{\sigma}$	$\pi\uparrow$ $q\downarrow$	$\pi\uparrow$ $q\downarrow$	$\pi\uparrow$ $q\downarrow$	$\pi\uparrow$ $q\downarrow$
4) $\sigma>\tilde{\sigma}>\varepsilon$	$\pi\uparrow$ $q\uparrow$	$\pi\uparrow$ $q\uparrow$	$\pi\uparrow$ $q\uparrow$	$\pi\uparrow$ $q\uparrow$
5) $\tilde{\sigma}>\sigma>\varepsilon$	$\pi\downarrow$ $q\uparrow$	$\pi?$ $q\uparrow$	$\pi\uparrow$ $q\uparrow$	$\pi\uparrow$ $q\uparrow$
6) $\tilde{\sigma}>\varepsilon>\sigma$	$\pi\downarrow$ $q\uparrow$	$\pi?$ $q\uparrow$	$\pi\downarrow$ $q\uparrow$	$\pi\uparrow$ $q\uparrow$

CONCLUSION

Content protection can benefit a country by lowering input prices and thereby output prices if the effect of lower input prices outweighs the effect of distortions in input use. It might also benefit a country by transfering foreign profits to domestic hands, even if input prices rise. The most favorable case for content protection would seem to be made if input prices fell and profits rose, which is possible. However, even in this case, since σ is small, the increase in costs due to distortions in input use is likely to be large and the price of the final product could well rise. The likelihood of welfare improvements through such policies does not seem very great. If domestic producers and labor are thought of as lobbying for protection in the hope of higher profit levels, our analysis makes it clear that they would not always wish to lobby for them, even if they are not set at unduly restrictive levels.

The basic idea we have focused upon in this paper is that content protection in an oligopolistic world changes the environment in which firms compete, and so affects their strategy. We have used a simple model to obtain some intuition about the nature and determinants of these changes. Our results suggest that substitution possibilities between inputs and the responsiveness of final demand to price determine in a fairly complicated manner the effects of such protection. These implications differ signficantly from those derived from models of other market structures.

We do have some ideas concerning future work along our lines. Firstly, different oligopoly models are notoriously prone to give different results and it would be interesting to see what such changes in the model yield.[18] We choose to model the game as a price game in this paper because the effect of protection on input demand by firms producing the final product is clearcut in such games.

Secondly, we only consider symmetric situations. We have no doubt that pure strategy equilibria can exist in non-symmetric situations, and that practically any result desired can be obtained by incorporating the appropriate asymmetry. However, this is precisely why we only allowed asymmetries that arise due to the form of the protection itself. One asymmetry which seems interesting is the one which results from changing the level of the constraint from the free trade level. This tends to increase the extent of the "C" effects and therefore affects the extent of "M" and "I" effects. We would like to understand such interactions better.

Finally, although we have analyzed the effects of content protection policies, we would like to point out the principle behind our analysis is a much broader one, with many other applications.

FOOTNOTES

1. However, it is conceivable that new equilibria could be created.

2. The demands for intermediate goods can be like those for complementary final goods, although the inputs are themselves substitutable in production. This is because the demand for intermediate goods is a <u>derived</u> demand. While an increase in one input's prices causes substitution away from it, and hence an increase in demand for the other input, it also lowers the demand for the other input as the cost of production of the final good rises. This increase in cost raises the price of the final good and lowers its demand, which reduces both input demands. Thus, the elasticities of demand for the final good ε, and of substitution in production, σ, are important in determining whether intermediate good demands are complements or substitutes. They are substitutes if $\sigma - \varepsilon > 0$ and complements if $\sigma - \varepsilon < 0$. See Hicks (1968) for a proof.

Best response functions could be upward or downward sloping. In the case where σ and ε are constants, an examination of the second derivatives, π_{ww*} and π^*_{ww*}, shows that they have the same sign as $(\sigma-\varepsilon)(\sigma-1)$ about the Nash equilibrium. This therefore gives the sign of the slope of the best response functions, as long as second order conditions hold. However, a case thought of as possible "a priori" - namely $\pi_{w*} > 0$, and $\pi_{ww*} < 0$, ($\sigma < 1$, and $\varepsilon < \sigma$) is not possible in the CES/CED case. This can be seen by noticing that in this case the elasticity of z with respect to w is always less than 1. Hence, no interior maximum to profits exists.

3. See Johnson (1963).

4. In his paper complementarity is defined by the marginal product rising with the use of the other input. This is always true if there are only two inputs and constant returns to scale.

5. The point that interaction effects can change equilibrium in surprising ways has been made by Krishna (1984) in her analysis of voluntary export restrictions and tariff-quota non equivalence under oligopoly. Our analysis is based on her work.

6. We assume throughout that the penalty for non-compliance is so great that compliance is ensured. Therefore, the actual penalty is irrelevant.

7. Notice that the preceding would be true even if the constraint was set in terms of using at least $\bar{a}$ to produce a unit of output.

8. It is also easy to verify that $\bar{\pi}(w,w^*) < \pi(w,w^*)$ if $w<\omega w^*$, but that the reverse is not necessarily so when $w>\omega w^*$.

9. The proof consists of showing that $\hat{\pi}^*$ is the minimum of two concave functions and therefore concave. These functions are π^* and a function which is $\bar{\pi}^*$ for w^* below ω/w and the tangent plane to $\bar{\pi}^*$ at ω/w for w^* above ω/w.

10. $\bar{B}$ and $\bar{B}^*$ are downward sloping as long as D is not too convex. They are positively sloped if D is convex enough as in the constant elasticity case.

We use the former case to illustrate the model. The results are not dependent on this pictoral representation and we say more about this later on.

11. It would be incorrect to define $\hat{B}(w*)$ to be $B(w*)$ whenever $\pi(B(w*),w*)$ exceeds $\bar{\pi}(\bar{B}(w*),w*)$, but to be $\bar{B}(w*)$ if the reverse is true, and to be both B and $\bar{B}$ if the two profit levels are equal. This is due to the possibility that $\pi(B(w*),w*)$ exceeds $\bar{\pi}(\bar{B}(w*),w*)$, but $B(w*)$ exceeds $\bar{\omega}w*$. In this event, $\hat{B}(w*) = \bar{B}(w*)$. For this to occur, both π_w, $\bar{\pi}_w$ must exceed zero along $\omega = \bar{\omega}$.

12. See Dasgupta and Maskin (1982).

13. Notice that the restriction has changed the nature of interactions between firms. Irrespective of whether best response functions are upward or downward sloping in the absence of the restriction, it becomes optimal for the foreign firm to raise price in response to price increases.

14. Formally, $\bar{a}*(\omega,\alpha)$ will be defined by $F(\bar{a}*(\omega,\alpha)d(\alpha,\omega), \bar{a}*(\omega,\alpha)) = 1$, and $\bar{a}(\omega,\alpha) = d(\omega,\alpha)\bar{a}*(\omega,\alpha)$ where $d(\omega A) = = \frac{\alpha}{(1-\alpha)}$. If $\omega > \bar{\omega}$ these are the cost minimizing input coefficients. If $\omega < \bar{\omega}$, the constraint is not binding, so the cost minimizing inputs will be $a(\omega)$ and $a*(\omega)$. However, we will define $\bar{c}(w,w*,\alpha)$ as being equal to $w\bar{a}(\omega,\alpha) + w*\bar{a}*(\omega,\alpha)$.

15. Another way of seeing how $\bar{z}_w(w,w*,\alpha)$ and $z_w(w,w*)$ differ is to notice that the only difference between them lies in the differing response of $a(\omega)$ and $\bar{a}(\omega, \alpha)$ to changes in w for a fixed w^*. If $\sigma>1$, an increase in w lowers $\bar{a}(\omega, \alpha)$ by less than it lowers $a(\omega)$ so that $\bar{z}$ is less elastic than z. Also, as the constraint binds for high w's the input demand function is made less elastic for input price increases so that profit maximization requires an increase in w. Similarly, $\bar{z}^*$ is also less elastic than z^*, but as the constraint binds for low w^*'s, there is no incentive to change price on the part of the foreign producer. If $\sigma < 1$, an increase in w makes $\bar{a}(\omega,\alpha)$ fall by more than $a(\omega)$ and $\bar{z}$ is more elastic than z. However, as the constraint binds for low w, lowering price is profitable for the domestic producer. As the constraint binds on the foreign firm for high w^*, and as $\bar{z}^*$ is more elastic than z^*, there is no reason for the foreign firm to change its price.

16. This is not possible in the CES-CED example mentioned earlier, as $1>\sigma>\varepsilon$ was not consistent with a bounded profit function.

17. This uses the facts that $\sigma = \eta+\eta*$ and $\eta\theta = \eta*\theta*$. Also, for the CES case $\frac{a}{a*} = \omega^{-\sigma}$ so that $\frac{\theta}{\theta*} = \omega^{1-\sigma}$. Letting $C = \omega^{1-\sigma}$ and solving for θ, $\theta*$, η, $\eta*$ in terms of σ and C, using the previous equalities, gives $\eta = \sigma/(1+C)$, $\eta* = \sigma C/(1+C)$, $\theta = C/(1+C)$ and $\theta* = 1/(1+C)$. Adapting these results when $Y = F(G(Z,Z*) L)$ gives the next equation in the text as follows. Define $\tilde{\phi}$ analogously to C as $\tilde{\phi} = (q/c)^{1-\sigma}$ where $c = c(w,w*)$, the unit cost of making the composite input, and q is the price of labor. If $\tilde{\sigma}$ is the elasticity of substitution between the composite input and labor, then $\eta_b = \tilde{\sigma}/(1+\tilde{\phi})$, $\eta_f = \tilde{\sigma}\tilde{\phi}/(1+\tilde{\phi})$, $\theta_L = \tilde{\phi}/(1+\tilde{\phi})$, and $\theta_x = 1/(1+\tilde{\phi})$. These relations are used later on as well.

18. See Sonnenschein (1968), Singh and Vives (1984), and Eaton and Grossman (1984) for some recent work on a point going back to Edgeworth and Bertrand.

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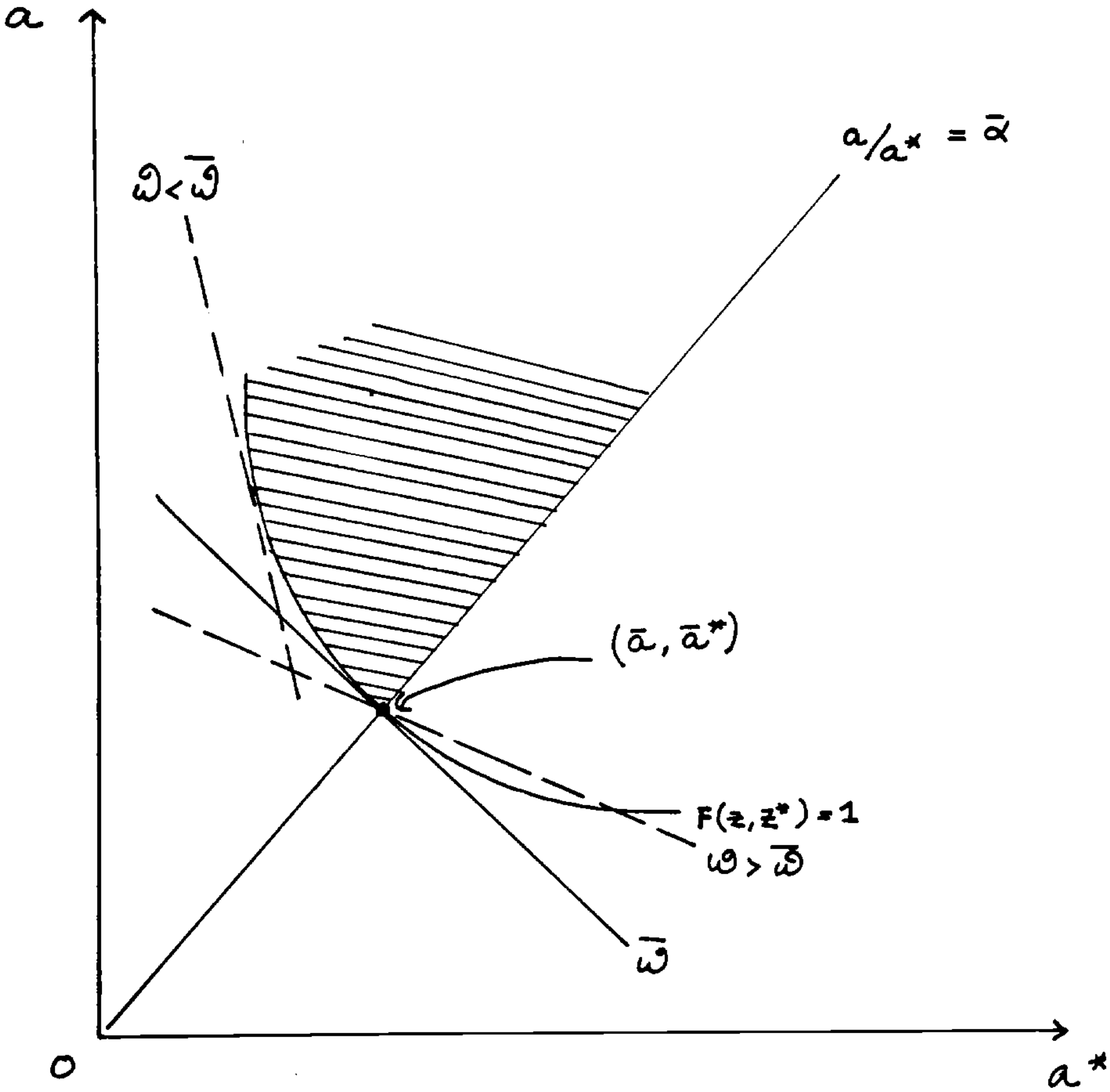
DIAGRAM 1



a
$\omega < \bar{\omega}$
$a/a^* = \bar{\alpha}$
$(\bar{a}, \bar{a}^*)$
$F(z, z^*) = 1$
$\omega > \bar{\omega}$
$\bar{\omega}$
O
a^*

DIAGRAM 2

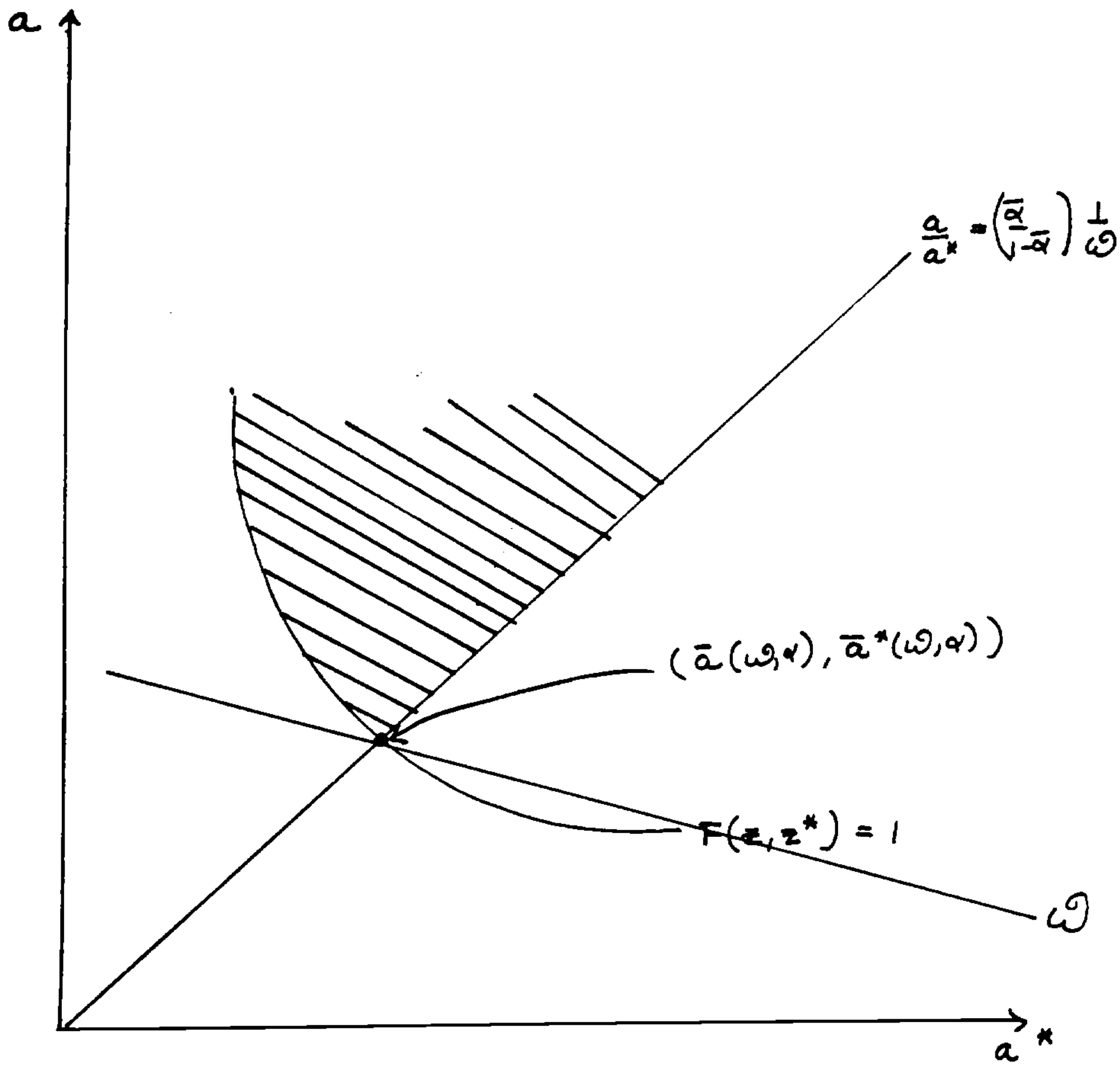

a
$\frac{a}{a^*} = \left(\frac{\bar{\alpha}}{1-\bar{\alpha}}\right)\frac{1}{\omega}$
$(\bar{a}(\omega,\alpha), \bar{a}^*(\omega,\alpha))$
$F(z, z^*) = 1$
ω
a^*

DIAGRAM 3

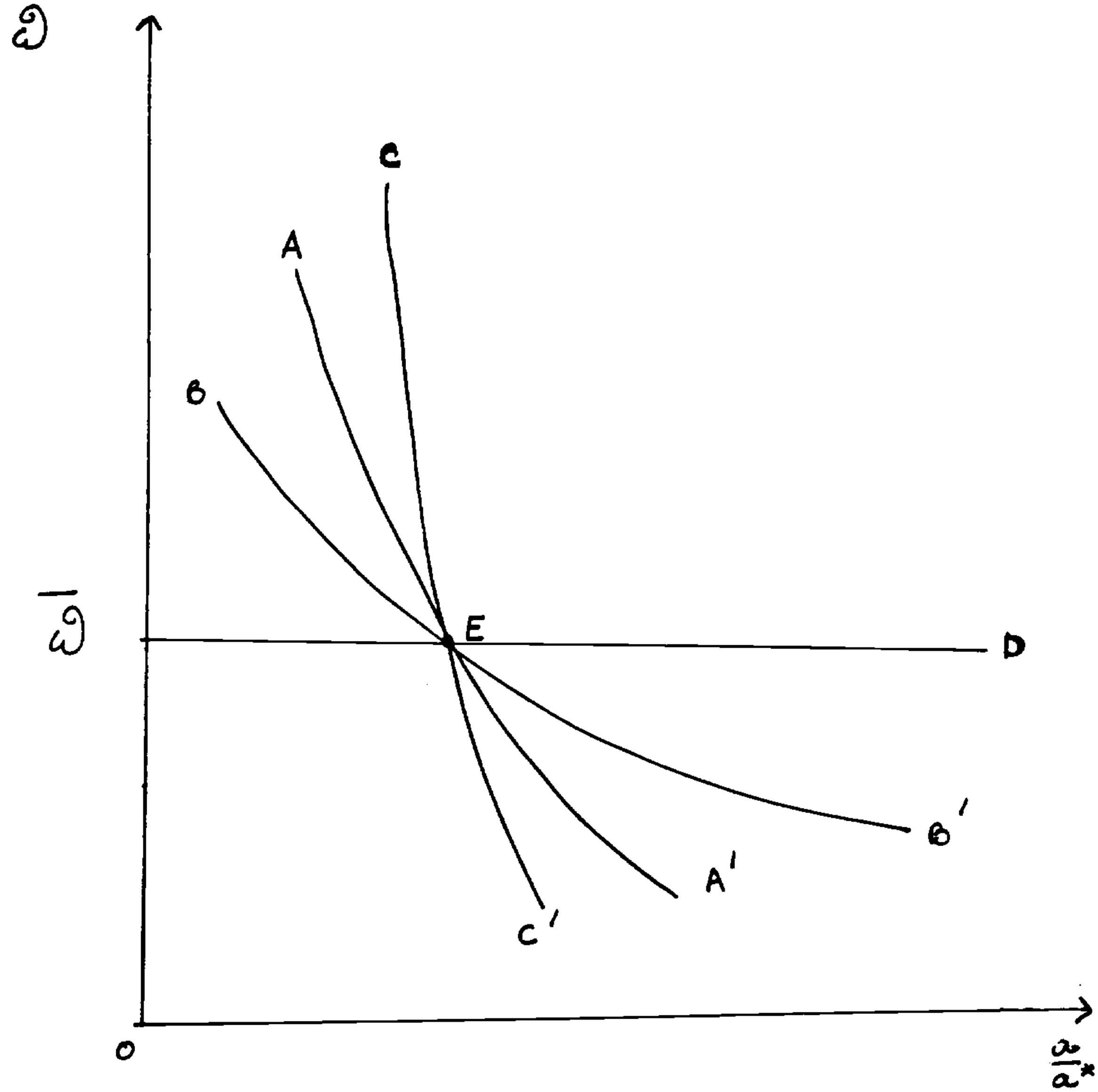


DIAGRAM 4

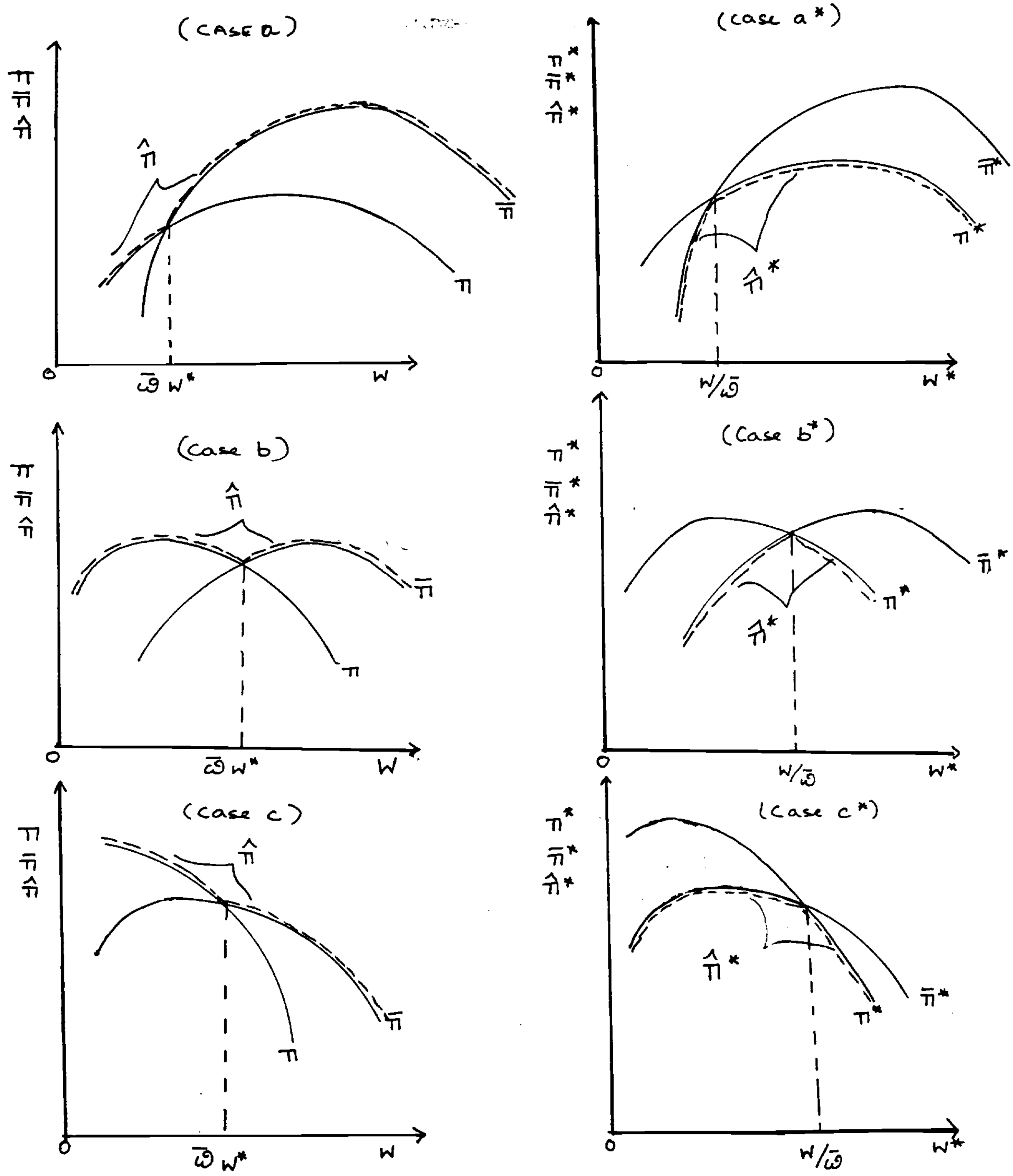

(CASE a)
(case a*)
(case b)
(Case b*)
(case c)
(case c*)
π $\bar{\pi}$ $\hat{\pi}$
π^* $\bar{\pi}^*$ $\hat{\pi}^*$
$\bar{\omega}$ w^*
$w/\bar{\omega}$
W
W*
0

DIAGRAM 5

(Complementary goods, PCP, or VACP and $\sigma > 1$)

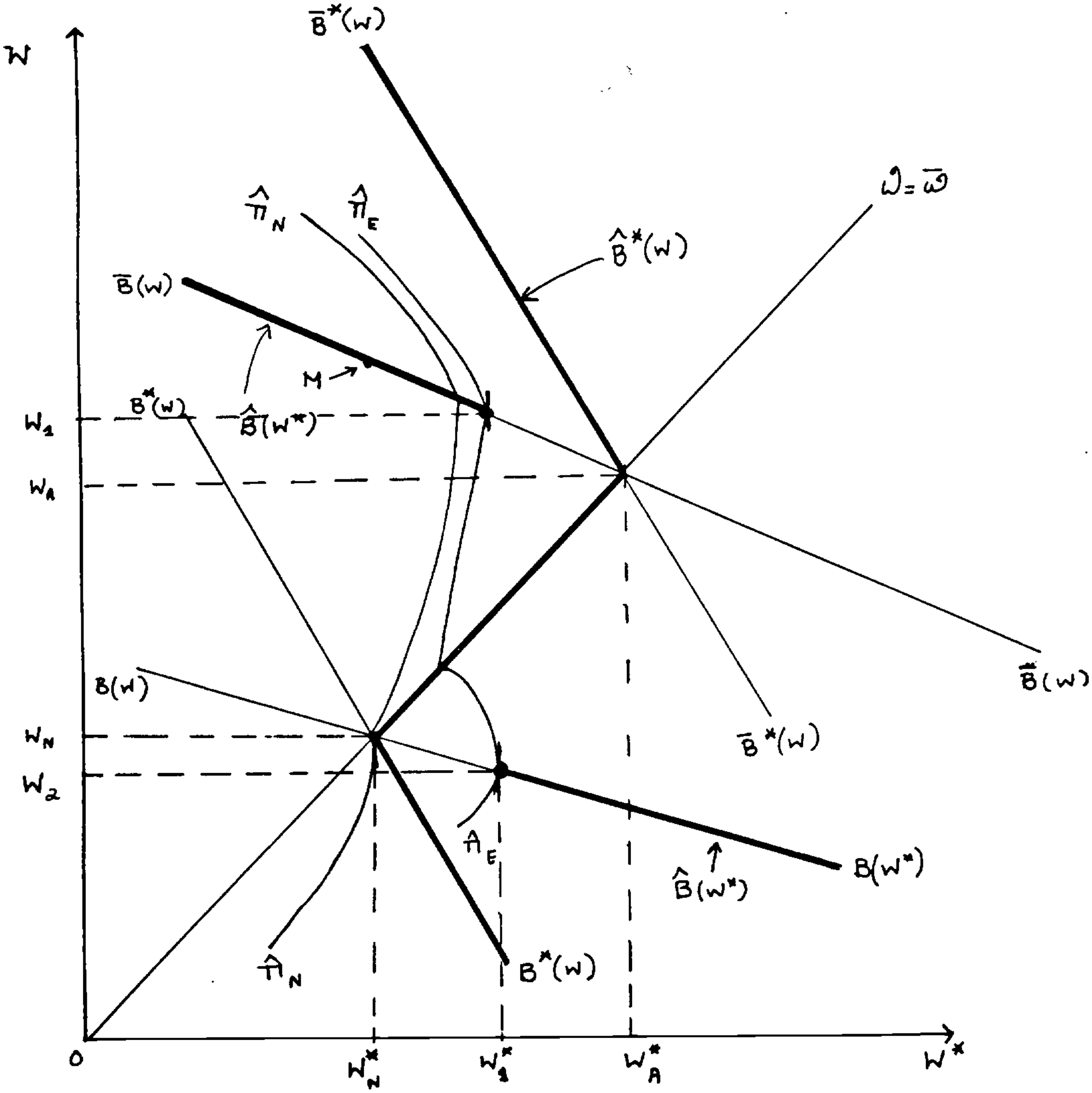


DIAGRAM 6

(complementary products, VACP, $\sigma < 1$)