

THE SIMPLE CASE OF ENTRY DETERRENCE RECONSIDERED

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## ABSTRACT

This paper reconsiders what I will refer to as the simple case of entry deterrence, i.e., a static framework wherein a single incumbent firm faces a single potential entrant and the entry deterring investment is sunk capacity. The paper demonstrates that one of the main conclusions of Dixit (1980) is not robust to changes in the technology considered. For example, if one changes the specification to a technology which Dixit himself suggested would be more plausible, then excess capacity results in the spirit of Spence (1977) become quite common. The paper also considers related issues such as whether incumbent firms will ever hold "idle capacity", and whether excess capacity would ever be held by an entrant.

## I. Introduction

From the late seventies to the mid eighties significant attention was paid to what I will refer to as the simple case of entry deterrence, i.e., a static framework wherein a single incumbent firm faces a single potential entrant and the entry deterring investment is sunk capacity.<sup>1</sup> In the late eighties, however, most economists seem to feel that this simple setting is sufficiently well understood that it no longer requires significant attention. The result is that attention has become focused on topics such as the role of entry deterring investments other than sunk capacity, the role of multiple incumbents and/or multiple potential entrants, and the importance of dynamics.<sup>2</sup> This paper reconsiders the simple case, and argues that the accepted wisdom concerning this case is incorrect.

The paper which stimulated the interest over the last decade on the topic of entry deterrence was Spence (1977).<sup>3</sup> Spence argued that an incumbent firm would sometimes hold "excess capacity" in order to deter entry, where excess capacity was defined as a level of capacity greater than the level which minimizes costs given the absence of entry. The logic put forth for this result was quite simple. Excess capacity would give the incumbent firm the ability to expand output if entry were to occur, and this threat would be sufficient to deter firms from entering. The drawback of the Spence analysis was that he did not take a formal game theoretic approach to the problem, and hence there was a question concerning whether the threat to expand output upon entry was really a credible one.

This is the issue addressed in Dixit (1980). Dixit assumed the incumbent and entrant would behave in a Cournot-Nash fashion upon entry, and then carefully derived the equilibrium under this assumption. What he found was

that although entry deterrence could occur, it would never involve excess capacity. That is, the holding of excess capacity was not a credible threat, and hence would never be part of equilibrium behavior.

Both Bulow et al. (1985) and Gilbert (1986) have argued that Dixit's result concerning the absence of excess capacity is not general. In particular, they point out that it is dependent on his assumption of a linear demand curve. The linear demand curve guarantees that the incumbent's marginal revenue curve is always decreasing in the other firm's output - or equivalently, that the incumbent's reaction curve is everywhere downward sloping.<sup>4</sup> If, for example, industry demand is of the constant elasticity type then this property will not be satisfied, and the holding of excess capacity becomes a possibility.

From reading the literature one might easily be left with the impression that the holding of excess capacity is a possible outcome, but not a very likely one. It seems to depend on the somewhat counter-intuitive property that, even though a Cournot-Nash game will be played upon entry, the incumbent firm will have an incentive to increase output if entry occurs.<sup>5</sup> What I show in this paper is that Dixit's result is not just dependent on the presence of downward sloping reaction curves. It also depends on the specific technology he employs for the incumbent firm. For example, if one changes the specification to a technology which Dixit himself suggested would be more plausible, then excess capacity results in the spirit of Spence become quite common.

The outline for the paper is as follows. Section II discusses the importance of the technology assumption. Section III presents and analyzes the Dixit model under a technology specification which Dixit suggested but

did not fully investigate. Section IV considers related issues such as whether an incumbent firm would ever hold "idle capacity", and whether excess capacity would ever be held by an entrant? Section V presents some concluding remarks.

## II. Why the Technology Assumption is Important

In his original paper Spence considered two different technologies for the incumbent firm. The first was a simplification of what we might expect real world technologies to look like. Let  $x$  be the output of the firm,  $k$  be the capacity level,  $r$  be the constant per unit cost of capacity,  $F$  be the fixed costs, and  $w$  be the constant marginal cost. Total costs, denoted  $TC(x,k)$ , were given by equation (1).<sup>6</sup>

$$(1) \quad TC(x,k) = \begin{cases} F+wx+rk & \text{if } x \leq k \\ \infty & \text{if } x > k \end{cases}$$

Equation (1) tells us that it is infinitely costly to produce an output which is greater than capacity, and an increase in capacity has no effect on the marginal cost for any output less than capacity. That is, given a sunk investment in capacity  $\bar{k}$ , marginal cost is given by equation (2) or Figure 1.

$$(2) \quad MC(x, \bar{k}) = \begin{cases} w & \text{if } x < \bar{k} \\ r+w & \text{if } x \geq \bar{k} \end{cases}$$

This is exactly the technology Dixit employed to show that, given a linear demand curve, excess capacity will never be part of equilibrium behavior. The intuition for the result is simple. The linear demand curve guarantees that if entry occurs the incumbent firm will decrease output. Hence, since the incumbent firm's reaction curve is determined by its own marginal cost schedule, holding excess capacity cannot be beneficial because

it will not affect the reaction curve for the firm in the relevant region.

Neither Spence nor Dixit felt the above technology was particularly plausible, but rather its supposed advantage was its simplicity. Thus, both authors also consider an alternative technology where an increase in capacity decreases marginal cost. For example, Dixit considers what happens when total cost for the incumbent is given by equation (3).

$$(3) \quad TC(x,k) = C(x,k), \text{ where } \frac{\partial^2 C}{\partial x \partial k} < 0$$

In analyzing this alternative case, however, Dixit does not consider whether it leads to a different conclusion concerning the holding of excess capacity. (Remember, Spence defined excess capacity as a capacity level which is greater than the level which minimizes costs given the absence of entry.) Given the logic above for why the initial technology assumed cannot lead to an excess capacity outcome, one might be somewhat dubious as to whether the no excess capacity result continues to hold for this case. That is, for the initial technology no excess capacity is held in equilibrium because excess capacity does not affect the firm's marginal cost in the relevant range. Now, however, holding excess capacity lowers marginal cost in the relevant range, and it would seem that equilibrium behavior could be characterized by excess capacity. The logic is that, because marginal cost is lowered in the relevant range, the presence of excess capacity shifts out the reaction curve of the incumbent in the relevant range. In turn, this clearly suggests that excess capacity can serve to deter entry.

One interesting point about this argument concerns its relationship to the argument originally put forth by Spence. The argument here is similar to Spence's argument in that the incumbent firm holds excess capacity. However,

it is also different in that the excess capacity is held for a much different reason. In the Spence argument excess capacity is held because it allows the incumbent to increase output if entry occurs. As Dixit correctly pointed out, however, given a linear demand curve this threat is not credible. What Dixit missed, on the other hand, is that there is an alternative reason for why an incumbent may hold excess capacity. In particular, what drives the argument above is that excess capacity may be held because it credibly commits the incumbent to not decrease output "as much" if entry occurs.

In the following section I consider this issue formally. What I show is that, indeed, once the more plausible technology is introduced, then holding excess capacity in order to deter entry becomes a quite common outcome.

### III. The Model

Other than the specification of a technology for the incumbent, the model I will consider is equivalent to the one considered by Dixit. There is a single incumbent firm, denoted firm 1, and a single potential entrant, denoted firm 2. The two firms face a linear industry demand curve, i.e., the inverse industry demand function is given by  $P(X)=A-bX$ , where  $X$  is industry output. Further, the timing of events inside the model is simple. The incumbent firm first decides on a sunk investment in capacity  $k_1$ . The potential entrant then observes this sunk investment in capacity and decides whether or not to enter, where entry occurs if and only if the potential entrant will achieve strictly positive profits upon entry. If entry does occur then the two firms play a Cournot-Nash game and the entrant incurs a cost  $F_2+cx_2$ .<sup>7</sup> If entry does not occur then the incumbent firm is simply a monopolist.

As indicated, except for the technology for the incumbent which has yet

to be specified, the above model is equivalent to the one considered by Dixit. The technology for the incumbent considered by Dixit is described by equation (1) of Section II. What I would like to do is consider a technology similar to the one described by equation (1), but which also satisfies equation (3), i.e., the technology must be such that an increase in capacity decreases marginal cost.

Let  $TC(x_1, k_1)$  again denote the incumbent firm's total cost of producing  $x_1$  units of output given capacity level  $k_1$ . It is now assumed that  $TC(x_1, k_1)$  satisfies the following:  $TC(x_1, k_1) = F_1 + VC(x_1, k_1)$ ,  $\frac{\partial VC}{\partial x_1} > 0$ ,  $\frac{\partial^2 VC}{\partial x_1^2} > 0$ , and  $\frac{\partial^2 VC}{\partial x_1 \partial k_1} < 0$ . That is, total cost is the sum of fixed and variable cost components, (short run) marginal cost is positive and upward sloping, and an increase in capacity decreases marginal cost. Let  $\hat{k}(x_1)$  be the function which defines the cost minimizing capacity level for any output  $x_1$ , i.e.,  $\hat{k}(x_1)$  is defined by equation (4).

$$(4) \quad \hat{k}(x_1) = \arg \min_k VC(x_1, k) \text{ for all } x_1 \geq 0$$

It is also assumed that the variable cost function is such that  $\hat{k}(x_1)$  satisfies the following two conditions:  $\hat{k}' > 0$  and  $\frac{d(VC(x_1, \hat{k}(x_1)))/x_1}{dx_1} = 0$ .<sup>8</sup> The first condition states that the cost minimizing capacity level is increasing in output. The second assumption makes this technology somewhat similar to the one initially considered by Dixit. It states that, given cost minimizing capacity choices by the incumbent firm, the average variable cost curve is horizontal.

The technology described above is pictured in Figure 2.  $AVC'$  represents the average variable cost curve given cost minimizing capacity choices by the incumbent firm. The other curves represent average variable cost and



corresponding marginal cost curves given fixed capacity choices. Obviously as we move to the right in the diagram the AVC and MC curves are those associated with higher capacity levels.

The question of interest is, given this more plausible specification for the incumbent firm's technology, will the incumbent firm ever hold excess capacity. That is, will it ever have an incentive to deter entry and at the same time have a sunk investment in capacity which is above that which is cost minimizing. The answer is yes. Proposition 1 tells us that there is always a range of values for  $F_2$  such that excess capacity is held in equilibrium.

Proposition 1: There are critical values  $\bar{F}$  and  $\underline{F}$ ,  $\bar{F} > \underline{F}$ , such that i), ii) and iii) are true.

- i) If  $F_2 \geq \bar{F}$ , then entry is deterred and  $\bar{k}_1 = \hat{k}(x_1)$ .
- ii) If  $F_2 < \underline{F}$ , then entry occurs and  $\bar{k}_1 > \hat{k}(x_1)$ .
- iii) If  $\underline{F} \leq F_2 < \bar{F}$ , then entry is deterred and  $\bar{k}_1 > \hat{k}(x_1)$ .

Proof: See the Appendix

Cases i), ii) and iii) above are analogous to the three outcomes discussed by Dixit. The first case is the case of blockaded entry. In this case entry is deterred if the incumbent firm makes a sunk investment in capacity equal to the capacity choice of an unconstrained monopolist. Given this condition, it should be clear the incumbent will have no incentive to hold excess capacity. Case ii) is where the fixed cost of the potential entrant is sufficiently low that the incumbent decides to allow entry, i.e., this is the case where entry is ineffectively impeded. Here the incumbent holds excess capacity, but the excess capacity is not held for entry deterrence purposes. Rather, excess capacity is held because it moves out the reaction

function of the incumbent, which in turn has the effect of reducing the output of the entrant once entry occurs.<sup>9</sup>

The important case, however, is case iii). In this case the fixed cost of the entrant is in an intermediate range such that entry is not blockaded, but the incumbent still has an incentive to deter entry. What is of interest here is that, as opposed to what Dixit found for this case, the incumbent decides to deter entry by holding excess capacity. The result is easily understood by considering Figure 3. In Figure 3 the minimum capacity choice which will deter entry corresponds to the cost curves  $AVC^d$  and  $MC^d$ . It is clear from the diagram, however, that if the firm decides to deter entry by sinking this amount of capacity, then it will only produce  $x^d$  and the cost minimizing capacity choice would be strictly smaller. In other words, exactly as suggested in the previous section, because excess capacity now lowers marginal cost, the incumbent deters entry by holding excess capacity.

#### IV. Related Issues

##### A) An Example With Idle Capacity

At this point the reader may wonder whether there is a way of at least partially saving Dixit's original conclusion. That is, although it should now be clear that in order to deter entry an incumbent firm may hold excess capacity, maybe Dixit's argument at least shows that in order to deter entry a firm would never wind up holding what I will refer to as idle capacity. By idle capacity I mean capacity with the property that, except for any direct capital cost expenditure, the extra capacity has no effect on the total cost of production.<sup>10</sup> In this sub-section I show that this conjecture is incorrect. In a model with technological improvement, in order to deter entry even idle

capacity may be held in equilibrium.

To demonstrate this point let us start with a simple example along the lines of Dixit's original analysis. Let everything be as in the model of Section III except for the technology of the incumbent. Further, make the following specific assumptions. Industry inverse demand is given by  $P=200-X$ , while  $F_2=3600$  and  $c=20$ .

The incumbent is endowed with a factory whose size is 75 units of capacity, where this factory satisfies the assumptions of equation (1). In particular, given this capacity the firm has a constant marginal cost of production equal to 30 for the first 75 units of output. To produce more, however, the firm would need to purchase additional capacity at a cost of 20 per unit, with the result being that for output levels greater than 75 the marginal cost of production jumps to 50.<sup>11</sup>

In this example there is no way for the incumbent firm to deter entry. The logic here is exactly that identified by Dixit. Whether the incumbent increases its investment in sunk capacity beyond 75 units or leaves it at 75, entry would result in the incumbent producing  $53\frac{1}{3}$  units, the entrant producing  $63\frac{1}{3}$ , and the entrant earning profits of approximately 411. In other words, since holding idle capacity does not affect the incumbent's marginal cost in the relevant range, there is no way that holding idle capacity can deter entry.

Now consider the slight variation on the example above which incorporates the possibility of technological improvement. Everything is the same except for the technology specification of the incumbent firm. The incumbent is again endowed with the factory described above. However, new units of capacity are superior to the capacity the firm is endowed with. In particular, as before new units of capacity cost 20 per unit, but now the

additional marginal cost of production is 20 instead of 30. By investing in 60 units of this new capacity the incumbent can deter entry. The reason is that investing in additional sunk capacity now lowers marginal cost in the relevant range, and hence, decreases the profitability of entry. The result is that the incumbent deters entry by purchasing an additional 60 units of capacity, and in its subsequent position as a monopolist it produces 85 units of output. What this means is that in order to deter entry the firm winds up holding 50 units of idle capacity.

B) Strategic Behavior By the Entrant

Ware (1984) has criticized Dixit's original specification on the grounds that it overly limits the scope for strategic behavior on the part of the entrant. What he argues is that if entry occurs, the entrant should have the same ability to make a sunk investment in capacity as did the incumbent. He then demonstrates that, if this capability is granted, the effect is a reduction in the ability of the incumbent to deter entry.

In Section III we abstracted away from this issue by not including a capital cost in the entrant's cost function (see footnote 7). The question which arises is, how would the analysis of Section III be affected if the entrant did have the ability to sink an investment in capacity. In particular, suppose it had this ability and it had the same type of cost function as that posited for the incumbent in Section III.

In terms of the actual statement of Proposition 1 there would be no change. That is, there would be two critical values for the fixed cost of the entrant, and i), ii) and iii) would still describe whether entry occurs and whether the incumbent holds excess capacity. There would, however, be a

difference in terms of the critical values themselves. Just as in Ware's analysis, granting the entrant the ability to sink an investment in capacity will make it more difficult to deter entry. This implies that  $\bar{F}$  will be higher, i.e., there will be a range of values of fixed cost for the entrant such that entry is blockaded when the entrant cannot sink an investment in capacity, but is not when he can. On the other hand, the change in  $\underline{F}$  would seem to be ambiguous. The reason is that, in addition to it being more difficult to deter entry, it will now also be more costly for the incumbent if entry occurs. In other words, the cost of deterring entry goes up, but so does the cost of having entry occur. Hence, it would seem that the range of values over which entry occurs could either increase or decrease.

A second point about this case concerns the behavior of the entrant if entry occurs. In the Ware analysis the entrant never held excess capacity in equilibrium. Given that we are now assuming the potential entrant is characterized by the technology of Section III, this is no longer the case. ii) of Proposition 1 states that when entry occurs the incumbent holds excess capacity. The reason is that holding excess capacity moves out the reaction function of the incumbent, which in turn reduces the output of the entrant once entry occurs. If the entrant has the same technology as the incumbent, however, then upon entry the entrant should face the same type of incentives as does the incumbent. Hence, when entry occurs in this case, it will be characterized by excess capacity on the part of both the incumbent and the entrant.

## V. Conclusion

This paper reconsiders the simple case of entry deterrence, i.e., a static framework wherein a single incumbent firm faces a single potential entrant and the entry deterring investment is sunk capacity. The paper demonstrates that one of the main conclusions of Dixit is not robust to changes in the technology considered. For example, if one changes the technology in a manner which Dixit himself suggested would be more plausible, then excess capacity results in the spirit of Spence become quite common. The paper also considers related issues such as whether incumbent firms would ever hold idle capacity, and whether excess capacity would ever be held by an entrant.

The main conclusion that I feel should be drawn from this paper is that the technology originally considered by Dixit is quite special, and one should be cautious in generalizing from analyses which employ such a technology. For example, Eaton and Ware (1987) use this technology to look at a model of sequential entry, and find results such as the absence of excess capacity in equilibrium, the equilibrium number of firms is the smallest that can deter entry, etc. From the analysis of this paper it is clear that these results are dependent on the technology considered and, in fact, it is likely that both results mentioned would be reversed if the technology considered in Section III were to be introduced.

Appendix

Proof of Proposition 1: Let  $x_1^m$  be the output choice made by a monopolist unconstrained by potential entry. Further, let  $\Pi_2^*$  be the profits earned by the potential entrant upon entry if  $F_2=0$  and  $\hat{k}_1=k(x_1^m)$ , and let  $\bar{F}=\Pi_2^*$ . Clearly if  $F_2 \geq \bar{F}$ , then the incumbent maximizes profits by setting  $\hat{k}_1=k(x_1^m)$ . This is true since this investment in sunk capacity will deter entry, and the incumbent earns the same profits as an unconstrained monopolist. This proves i).

Consider two values  $F_2'$  and  $F_2''$  such that  $F_2' < F_2'' < \bar{F}$ . Suppose entry occurs (does not occur) when  $F_2=F_2''$  ( $F_2=F_2'$ ), and call  $\Pi_1'$  ( $\Pi_1''$ ) the corresponding level of profits for the incumbent firm. When  $F_2=F_2''$  the incumbent could have earned  $\Pi_1'+\epsilon$  by sinking  $\delta$  less than the capacity investment that corresponds to  $F_2=F_2''$ . Similarly, when  $F_2=F_2'$  the incumbent could have earned  $\Pi_1''$  by sinking the capacity investment that corresponds to  $F_2=F_2''$ . By revealed preference we now have a contradiction. Hence, there must be a critical value  $\underline{F}$ ,  $\underline{F} \geq 0$ , such that entry occurs if  $F_2 < \underline{F}$  and does not occur if  $F_2 \geq \underline{F}$ . Further, given  $\hat{k}' > 0$  one can also show that  $\bar{F} > \underline{F}$ .

Suppose  $\underline{F} \leq F_2 < \bar{F}$ . From a previous argument it must be the case that  $\hat{k}_1 > k(x_1^m)$ . In turn, from Figure 3 and  $\hat{k}' > 0$  we now have  $\hat{k}_1 > k(x_1)$ . This proves iii). Finally, ii) follows from the analysis in Dixit, pp. 103-105.

Footnotes

<sup>1</sup>Papers concerned with this case include Wenders (1971), Spence (1977), Dixit (1979,1980), Spulber (1981), Perrakis and Warskett (1983), Ware (1984), Bulow et al. (1985), Arvan (1986), and Gilbert (1986).

<sup>2</sup>Papers on these topics include Spence (1979), Eaton and Lipsey (1980), Kreps and Wilson (1982), Milgrom and Roberts (1982), Fudenberg and Tirole (1983,1984), Bernheim (1984), Gilbert and Vives (1986), Kirman and Masson (1986), Eaton and Ware (1987), Harrington (1987), McLean and Riordan (1987), and Waldman (1987).

<sup>3</sup>See also the earlier work of Wenders (1971).

<sup>4</sup>Spulber (1981) is open to the same criticism in that he assumes the demand curve is concave.

<sup>5</sup>In fact, Gilbert does some calculations using empirically measured capital costs, and concludes that in practice it is unlikely an incumbent will invest in sunk capacity beyond the monopoly level.

<sup>6</sup>Spence's analysis specified no fixed cost. I have included it here to make the technology consistent with that considered by Dixit.

<sup>7</sup>Dixit actually considers the cost function  $F_2 + rk_2 + cx_2$ . However, that specification opens up the possibility not considered by Dixit that the entrant will sink an investment in capacity prior to his production decision (see Ware (1984)). In this section I abstract away from this issue by not giving the entrant a capital cost. In Section IV I discuss how the analysis would change if this type of behavior by the entrant were allowed.

<sup>8</sup>Following Dixit, it is also assumed that for any fixed  $x_1$ , VC is decreasing in  $k_1$  up to  $\hat{k}(x_1)$ , and increasing thereafter.



<sup>9</sup>Dixit derives this result in his analysis of the type of cost function considered in this section.

<sup>10</sup>Traditionally authors in the literature have not drawn a distinction between excess capacity and idle capacity. For example,

"Dixit showed that Spence (1977) had studied an imperfect equilibrium (that is, an equilibrium that depended upon a threat that was not credible) to obtain his result that firms might hold excess capacity to deter entry. In a perfect equilibrium, a firm would not wish to install capacity that would be left idle if entry did not occur..."

(Bulow et al. (1985), p. 178)

<sup>11</sup>If we considered a full two period example where the incumbent was a monopolist in the first period, then 75 units would be the amount of capacity the firm would purchase for the first period.

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Figure 1

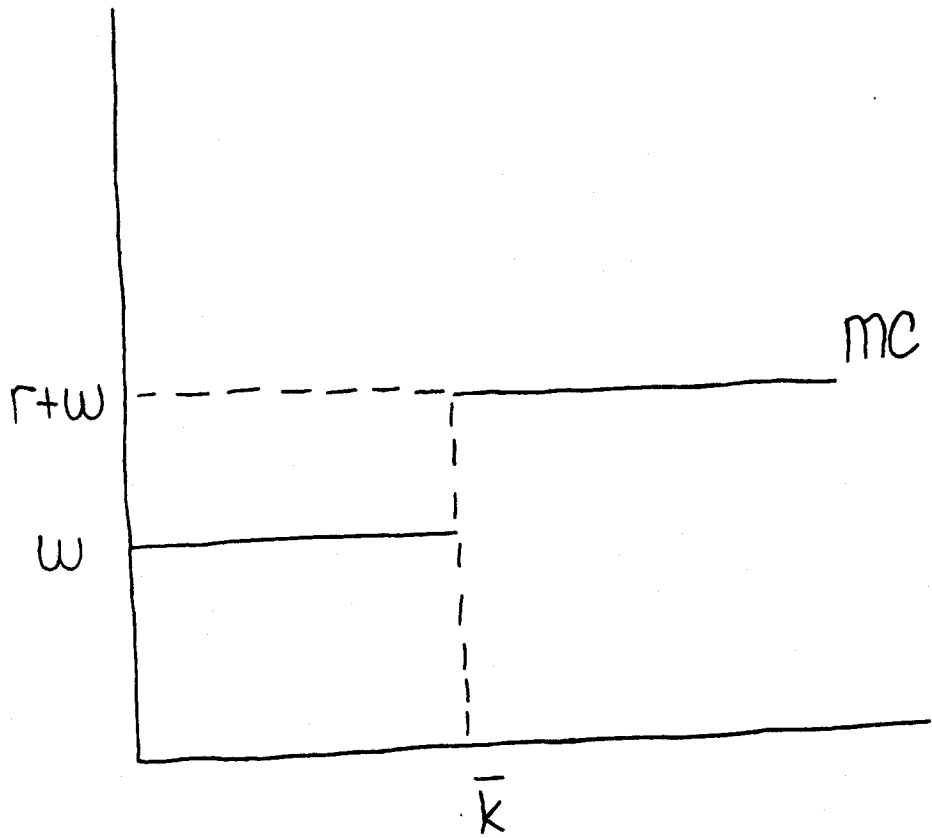


Figure 2

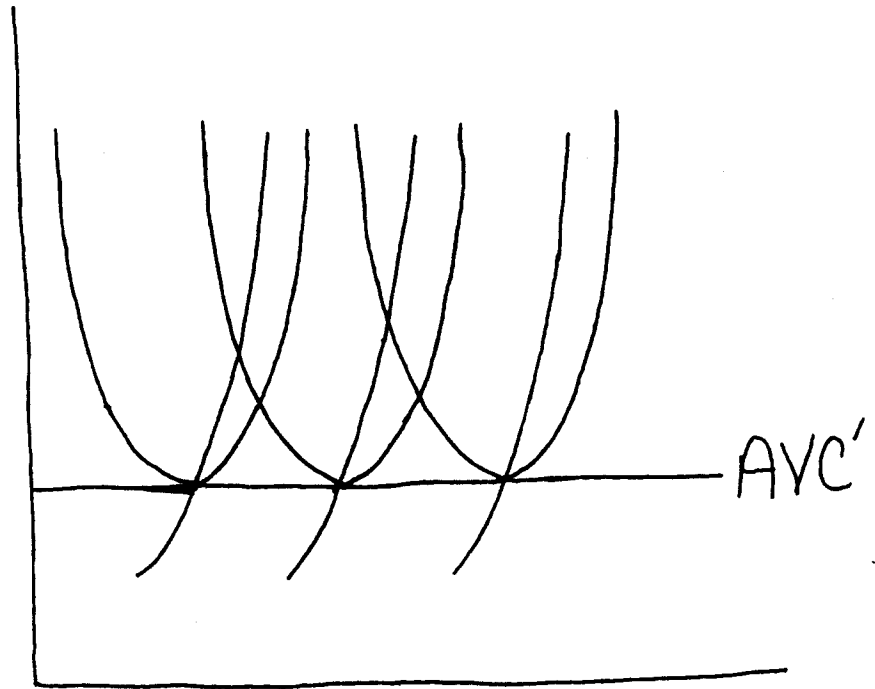


Figure 3

