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DISECONOMIES: A THEORETICAL DEPICTION**

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ABSTRACT

Introduction

Under the various types of externality defined on the basis of which entity or entities are involved and the direction of the effect, diseases and other health and physical hazards are theoretically depicted using as conceptual framework the relationship between (a) production functions; (b) production functions and utility functions; and, (c) utility functions. In all cases considered, the concomitant optimality conditions that rectify the distortionary effect of externalities are defined.

Externalities are generally attributed to the lack of enforcement of property rights because exclusion is not possible or property rights have not been clearly defined or are very difficult to define (Coase, 1960). This situation may have more bearing on less developed countries than on developed countries. In many less developed countries, notably where some open frontiers still exist, property rights on forests land, waterways and other bodies of water have not yet been assigned. Also, among many less developed countries where slums are prevalent, property rights are not assigned and therefore not enforced because slums are "tolerated" due to external

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*Casimiro V. Miranda, Jr.*¹

I. Introduction

Broadly defined, externality is the uncompensated effect or effects on others of someone else's activity or behavior. So defined, a concomitant feature of externality is that whether the affected party likes it or not, it has to bear its impact. The party whose activity or behavior emits the externality may be a firm engaged in production, or an individual. On the other hand, the affected party (or parties) may also be a firm (or firms), or a person (or persons). For a wider perspective of the definition, "inaction or an uncaring attitude" also constitutes an activity or behavior provided that it has effluents that affect others. If the externality or effect is beneficial, it is called positive externality or external economy, while if it is harmful it is called negative externality or external diseconomy.

Externalities are generally attributed to the lack of enforcement of property rights because exclusion is not possible or property rights have not been clearly defined or are very difficult to define (Coase, 1960). This theorem may have more bearing on less developed countries than on developed countries. In many less developed countries today where some open frontiers still exist, property rights on frontier land, waterways and other bodies of water have not yet been assigned. Also, among many less developed countries where slums are prevalent, property rights are not assigned and therefore not enforced because slums are "tolerated" due to extreme

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poverty. These are instances relating to the former problem while for the latter, there is the impossible assignment of property rights on the atmosphere which is true in all countries. In both cases though, it is clear that exclusion is hardly possible.

From the definition and classification of externalities, most diseases and other health and bodily hazards are external diseconomies, provided only that they can be shown to be the effects on others of the activity or behavior of a production entity or an individual. This proviso is very important because the same diseases or health and bodily hazards may have cause or causes other than the activity or behavior of a party. Included in these, for example, are a few non-hereditary congenital and systemic ailments. This paper will deal only with those diseases and other hazards to health and body that can be clearly identified as the harmful effect or effects of someone else's activity or behavior.

While the business of actual identification properly belongs to physicians and other health workers, there are however numerous clear cases of external diseconomies that can be cited some of which are:

- 1) Cancer that has been reported to have been induced or caused by the Chernobyl nuclear power plant accident in 1986 in the former Soviet Union. Such a nuclear power plant accident has also been reported at Lucens in Switzerland, and Three Mile Island in the United States although no casualty has been reported.

- 2) Cancer, emphysema, and other respiratory ailments contracted by those working at, or living in, the vicinity of a chemical processing plant that emits carbon in Copsa Mica, Romania, during the time of Nicolae Ceausescu; also those caused by smoke emitted by factories and cars or cigarettes.

3) Mercury poisoning reported in Minamata, Japan in the early 1970s due to improper disposal of mercury-contaminated wastes.

4) The toxic gas which killed at least 2,300 and injured more than 200,000 in Bhopal, India in 1984, due to a leak in Union Carbide India's chemical plant.

5) In many less developed countries today, such dreaded diseases as malaria, cholera, dysentery, typhoid fever, hepatitis, schistosomiasis and other infectious and parasitic diseases, among many others, have been identified in countless medical literatures and reported by the mass media almost daily, to have been caused by polluted waterways, lakes and other bodies of water, and the soil, which have been turned into a huge communal garbage dump for all kinds of wastes by factories and slum-dwellers along riverbanks, streams and lakeshores, and even along seashores.

These cases would suffice to support the idea that there are indeed diseases that are evidently external diseconomies. Furthermore, such diseases as cholera, dysentery, typhoid fever, and hepatitis are known to be communicable and thus, once contracted, they generate their own external diseconomies having their own dynamics. In the same vein, the dreaded AIDS and other sexually-transmitted diseases too can be considered as external diseconomies. Hereditary diseases are also included in this category insofar as they possess that feature of transferrability although the process is intergenerational and confined to a common lineage. Lastly, insofar as physical harm that can be inflicted by a by-product of someone else's behavior is concerned, one which can be considered as an external diseconomy is bodily harm inflicted on others by drug-abusers.

With regards to the various diseases, a list is provided in the appendix which classifies the diseases according to their medium of transmission. The list does not pretend to be exhaustive but is simply intended to show some of the more deadly diseases according to their general mode of transmission namely, air, water, and soil. The mode of transmission plays an extremely important role for most diseases to be called external diseconomies since whatever is emitted by the activity or behavior must be transported to the affected party (or parties). Thus air, water, and soil pollution or contamination by someone else's activity or behavior become external diseconomies when they take their toll.

Finally, by way of summing up this introduction, it is the objective of this study to show that most diseases including other forms of health and physical harm can be explained in economics as external diseconomies of production or consumption and other activity or behavior. With this objective, external economies are evidently out of consideration.

II. Theoretical Depiction of Diseases and Bodily Harm as External Diseconomies

To begin with, the types of externalities are determined depending on which of the two basic economic activities of production and consumption the emitter of the externality and the affected party belongs. On the basis of this, the four major types of externalities in which the firm is the specific entity under the production activity while the person or individual is the specific entity under the consumption activity are:

	<u>Emitter(s)</u>	<u>Affected Party(Parties)</u>	<u>Symbol</u>
1.	Firm	Firm	(F→F)
2.	Firm	Person	(F→P)
3.	Person	Firm	(P→F)
4.	Person	Person	(P→P)

Since the focus of this paper is on diseases and physical hazards as external diseconomies, only the second, third, and fourth types are relevant in the discussions that follow.

A. (F→P) External Diseconomy

Let the production function of the Fth firm, the emitter of the external diseconomy be

$$Q_F = F(L, K), \quad F=1, 2, 3, \dots, P \quad (A-1)$$

where L is the labor input while K is the non-labor input (capital or land, or some composite of both) the use of which by the firm to produce its output generates harmful effluent.

$$\text{Let } U_j = j[X_{ij}; Y_{ij}(K)], \quad i=1, 2, 3, \dots, n; \quad j=1, 2, 3, \dots, m \quad (A-2)$$

be the utility function of the jth person affected by the externality. $X_{ij} \geq 0$ is the quantity of the ith good or service ordinarily consumed by consumers, while $Y_{ij} > 0$ is the quantity of the ith medical good and service (medicines, physician's services, hospital services, etc.) which the jth individual must consume due to the disease or physical harm inflicted on him by the effluent

of F's input K. Thus Y_{ij} represents the ailment contracted by the jth individual the severity of which rises with F's use of K.

Q_F may be used in (A-2) in lieu of K but K is more straightforward and allows Q_F to appear as one of X_i in the utility function the marginal utility of which is positive.

As a quantitative representation of the affliction caused by K, Y_{ij} has the advantage of being readily measurable empirically. With Y_{ij} as the ailment, its marginal utility to the jth individual must be negative so that from (A-2),

$$\partial U_j / \partial K = \frac{\partial U_j}{\partial Y_{ij}} \frac{\partial Y_{ij}}{\partial K} < 0 \quad (A-3)$$

$\partial U_j / \partial Y_{ij} < 0$ also portrays the fact that it is the decrease in the quantity of medical goods and services consumed that indicates the turn for the better of the affliction. An important distinction between the goods or services X_{ij} and Y_{ij} should be noted. While some or all of X_{ij} can be zero, Y_{ij} is strictly positive due to its imperative nature.

With no external diseconomy in production, the optimality condition in a competitive economy is

$$P_{Q_F} = MC_F \quad (A-4)$$

where P_{Q_F} is the price of Q_F and the marginal benefit MB_{Q_F} that society derives from the output, and MC_F is F's marginal cost of Q_F and is also society's marginal cost of Q_F . However, with the external diseconomy emitted by F, (A-4) must be rewritten to account for the externality as follows:

The optimality condition in (A-5) or (A-6) where the externality in this case is accounted for remain the same since $MD_K = MB_{QF} - MC_F + \sum_{j=1}^m MD_{Kj}$ (A-5)

where MD_{Kj} is the marginal damage inflicted by the input K of firm F on the jth party and is shown in (A-3). Thus at the socially optimum level of Q_F the social marginal cost after taking into account the external diseconomy is the right-hand side of (A-5).

Alternatively, emitter F's socially optimal use of K requires that F equates the price of K, r_K , to the social marginal benefit of K's employment, i.e.

$$r_K = P_{QF} MP_K + \sum_{j=1}^m MD_{Kj} \quad (A-6)$$

where MP_K is the marginal product of K.

The above is a theoretical depiction of the (F→P) type of negative externality in which the impact on the affected party (or parties) of the activity of emitter F is direct, that is, the affliction is not necessarily communicable. If, however, the disease is communicable, then the utility function of the recipient of the ailment from the jth person should be included to reflect interpersonal utility externality. The utility function of the kth recipient of the ailment from j takes the form

$$U_k = k[X_{ij}, Y_{ik}(Y_{ij})] \quad j, k=1, 2, 3, \dots, m \quad (A-7)$$

where Y_k is the quantity of the ith medical good or service which the kth party infected by j must consume, and also represents the ailment.

The optimality conditions in (A-5) or (A-6) when the externality in this case is accounted for remain the same since $MD_{K_j} = MD_{j,k}$. The efficiency or optimality condition in consumption,

$MRS_{X_{ij}Y_{ij}} = MRS_{X_{jk}Y_{jk}} = P_{X_i}/P_{Y_i}$, $j \neq k$, which is the equality of the marginal rates of substitution of X_i for Y_i of the j th and k th consumers and the relative prices of the goods is not violated if the firm's output is not one of X_i . If it is, however, then the efficiency condition in consumption is violated because although the marginal rates of substitution may be equal, they are no longer equal to the relative prices of X_i and Y_i since if the externality

were to be corrected, the condition for social optimum is $P_{OF} = MB_{OF} = \sum_{j=1}^m MD_{Kj}$, so that $P_{X_i} \neq P_{OF}$.

In the above case where the illness emitted by F 's activity is communicable the more appropriate type of externality should be $(F \rightarrow P \rightarrow P)$ in which the $(F \rightarrow P)$ part shows the initial direct impact while the succeeding $(P \rightarrow P)$ part depicts the communicable nature (secondary impact) of the externality. Whether the impact is direct or indirect however, the externality is unidirectional.

B. $(P \rightarrow P)$ External Diseconomy

This type of externality differs from what has just been discussed in that here the firm (F) has absolutely no involvement but only consumption or, in general, the activity or behavior of individuals. While in the $(F \rightarrow P)$ or $(F \rightarrow P \rightarrow P)$ type of external diseconomy the locus of responsibility is clearly the firm, in the case at hand the emitter or emitters of the negative externality are the people themselves. This type of externality abounds among many poor countries today. The unhygienic practices of slum-dwellers along the banks of waterways or other bodies of water, who turn the rivers, lakes, and the sea including the surrounding land areas into a veritable garbage dump for all kinds of organic and inorganic refuse is clearly the

activity or behavior that generates this killer case of external diseconomy. Such untrammelled environmental abuse backfires with a vengeance as the waterways and other bodies of water and the surrounding land areas become a highly fertile breeding ground for many dreaded and highly contagious diseases such as malaria, hepatitis, schistosomiasis, cholera, dysentery, typhoid fever, helminthiasis and parasitic diseases, to name a few. In developed countries, the most common form of environmental abuse is air pollution.

For a broader scope and perspective, other infectious diseases such as the deadly AIDS, and other sexually-transmitted diseases are included under this type of external diseconomy. Hereditary diseases too, fall under this type of externality insofar as these disorders have the feature of being transferred from one person to another - although between generations in a lineage - very much like communicable diseases. Here, however, the decision to beget offsprings is the behavior that generates the external diseconomy. This behavior is shown in the individual's utility function by the appearance of goods and services related to childbearing and childrearing which have positive marginal utilities. All of these cases under the (P→P) type of externality can be approached in terms of interpersonal utility externality.

1. Environmental Abuse Case

Consider the case where diseases are generated by environmental degradation. The utility function of the j th individual is of the form

$$U_j = U_j[X_{ij}; R_j; Y_{ij}(R)], \quad i=1, 2, 3, \dots, n; \quad j=1, 2, 3, \dots, m \quad (B-1)$$

where, as in Sec. A, X_{ij} is the quantity of the i th good or service ordinarily consumed by the j th

person, R_j is the amount of garbage dumped by the j th person in his surroundings including the atmosphere and is a measure of his use and abuse of his environment and like X_{ij} its marginal utility is positive. R_j may be zero for some individuals to allow for the possibility that not all are guilty of the undesirable practice. Y_{ij} has the same interpretation as before - it is the amount of the i th medical good or service that the j th individual who contracts the disease must consume and represents the disease so that its marginal utility is negative. $R = \sum_{j=1}^n R_j$ is the total filth which all those in the community engaged in the wrongdoing has generated. It is R which is present in all of the utility functions of the individuals in the community that represents the backlash or the harmful impact of the people's abuse of their environment. Thus R is the source of the ailment Y_{ij} the severity or the extent of which rises with R . Consequently, from (B-1),

$$\frac{\partial U_j}{\partial R} = \frac{\partial U_j}{\partial Y_{ij}} \frac{\partial Y_{ij}}{\partial R} < 0 \quad (B-2)$$

If the disease which was initially contracted by the j th person is communicable, then the utility function of the k th infected party is

$$U_k = k[X_{ij}; R_k; Y_{ik}(R)], \quad j, k=1, 2, 3, \dots, m \quad (B-3)$$

In the case depicted above, although there must be some who initially acquired the disease and are clearly the emitters, they cannot however be identified since regardless of whether R_j is positive or zero, all individuals have R in their utility functions. Also, even if R_j is positive for all individuals, R_j alone cannot be held accountable for the externality. By reason of R however,

all members of the community can be emitters and due to the communicable nature of the disease, the external diseconomy may go beyond the community.

It is clear though from the circumstances of this case that the environment has been used as though it were a public good hence all are accountable for the external diseconomy (much like the congestion of a public good which is a disutility). Under these conditions, the effect of the external diseconomy on the optimality condition must be approached with the use of Samuelson's optimality condition of the supply or use of a public good which states that, without externality of any form,

$$\sum_{j=1}^n MB_{Rj} = MC_R \quad (B-4)$$

that is, the sum of the marginal benefits $MB_{Rj} = \partial U_j / \partial R_j > 0$ to all users of the environment (public good) represented by R must be equal to the marginal cost of making it available, MC_R .

Since the external diseconomy injects the distortion that makes the social marginal cost of R , SMC_R to be greater than MC_R then to correct for the negative externality, (B-4) should be rewritten as follows:

$$\sum_{j=1}^n MB_{Rj} = MC_R + \sum_{j=1}^n MD_{Y_{ij}(R)} \quad (B-5)$$

where SMC_R is the right-hand side of (B-5), and the marginal damage of R to the j th individual, $MD_{Y_{ij}(R)}$ is (B-2).

2. AIDS and other Sexually-transmitted Diseases

With regards to AIDS and other sexually-transmitted diseases, the theoretical depiction of these as external diseconomies is based on the idea that the sexual conduct and motive of the emitter generates the externality. Clearly, this activity is a form of leisure which has positive marginal utility and can be placed as an independent variable in the utility function. However, since leisure is too broad a term and connotes all non-labor time, the more specific goods and services complementary with leisure are instead used in the utility function to represent leisure. The important advantage that is gained from this is that all of the independent variables in the utility function of the emitter or affected party are quantities of goods and services.

As in the preceding cases involving common infectious afflictions, the direction of causation here is unilateral that is, from the emitter who is the bearer of the ailment, to the affected party who, prior to the sexual contact, is free of the disease. Blood transfusion and use of contaminated syringe are among those mentioned as the usual modes of transmission of the disease but sexual contact remains to be the most common mode of transmission. In any case, the interpersonal utility externality approach is again employed and all that is needed is the specification of the appropriate utility functions.

The respective utility functions of the j th emitter and the k th recipient of the negative externality are:

$$U_j = j(X_{1j}; X_{hj}; Y_{1j}) \quad (B-6)$$

$$U_k = k[X_{ik}; Y_{ik}(X_{hj})], \quad h, i=1, 2, 3, \dots, n; \quad j, k=1, 2, 3, \dots, m \quad (B-7)$$

where X_i is the quantity of the i th ordinary good or service consumed by the j th and k th individuals, X_{hj} is the h th good or service which is strictly complementary with leisure (representing j th's sexual activity) consumed by the emitter. X_{hj} is present in the utility function of the k th individual and on which the disease that he receives from the j th emitter, Y_k , depends. This means that the k th recipient of the illness acquires it from the j th emitter through his direct involvement and participation in the sexual activity of the emitter. Without direct sexual contact between j and k , there is no transfer of the ailment. Hence Y_k directly depends on j th's affliction Y_j . Thus Y_j or Y_k has the same meaning as before. The seriousness of the disease Y_k transmitted by j to k increases with increased sexual contact, X_{hj} , but since the marginal utility to the k th recipient of the illness, Y_k , is negative then

$$\frac{\partial U_k}{\partial X_{hj}} = \frac{\partial U_k}{\partial Y_k} \frac{\partial Y_k}{\partial X_{hj}} < 0 \quad (B-8)$$

(B-8) is the external diseconomy or marginal damage $MD_{X_{hj},k}$ inflicted by the j th individual to the k th recipient which, if accounted for, the optimality condition that must be satisfied is

$$MB_{X_{hj}} = P_{X_h} + \sum_{k=1}^n MD_{X_{hj},k} \quad (B-9)$$

3. Hereditary Diseases Case

Hereditary diseases may also be depicted similarly as AIDS and other sexually-transmitted afflictions since both are external diseconomies of sexual activity but the important difference is that in the case of hereditary diseases, there is the motivation to bear children which goes along with sexual activity in which the inheritor of the ailment has no participation. The utility functions in (B-6) and (B-7) are applicable with amendments in (B-7). In both utility functions though, X_i should now include goods and services related to child-bearing and child-rearing. While the utility function of the j th individual who bequeaths the affliction is (B-6), the utility function of the inheritor of the malady who belongs to any of the generations following j 's in the same lineage should be modified by changing the subscript of Y_k to depict what is now a case of inter-generational utility externality. With the j th individual as the initial transmitter, the inheritor of the ailment is $j+k$ ($j,k=1,2,3,\dots,\infty$). The subscript $j+k$ also indicates the generation to which the inheritor or inheritors of the disease belong. Since X_{ij} (representing j 's sexual activity with the motivation to procreate) is not in the utility function of $j+k$ the ailment, $Y_{i,j+k}$, inherited by him will depend only on the same ailment Y_{ij} of the j th emitter. Thus the utility function of the $(j+k)$ th inheritor of the disease takes the form

$$U_{j+k} = u[X_{i,j+k}; Y_{i,j+k}(Y_{ij})] \quad (B-10)$$

from which the marginal utility of the illness is negative so that the external diseconomy or marginal damage bequeathed by j to $j+k$ is

$$\partial U_{j+k} / \partial Y_{ij} = \frac{\partial U_{j+k}}{\partial Y_{i,j+k}} \frac{\partial Y_{i,j+k}}{\partial Y_{ij}} < 0 \quad (B-11)$$

The optimality condition that takes into account this external diseconomy is similar to (B-9) and is written as

$$MB_{X_{kj}} = P_{X_h} + \sum_{j=k}^{\infty} MD_{Y_{ij}, j+k} \quad (j, k=1, 2, 3, \dots, \infty) \quad (B-12)$$

4. Drug Abuse Case

As the last case of the (P→P) type of externality to be considered, there is the external diseconomy of drug-abuse behavior or activity which comes under "physical or bodily harm as negative externality." The effluent of such a behavior is the dreadful personality that the drug-abuser emits.

Although the j th emitter's utility function may take the form

$$U_j = j(X_{ij}; Y_j), \quad j=1, 2, 3, \dots, m \quad (B-13)$$

there are, however, very significant differences with the preceding cases. (1) Y_j is now the quantity of the various dangerous drugs consumed by the j th drug-abuser, and (2) while Y_j in the previous cases is an imperative commodity and represents the ailment so that its marginal utility is negative, the drug-abuser's Y_j is a highly desirable imperative commodity hence its marginal utility to the emitter is strictly positive.

The utility function of the k th party who may be affected by the negative externality is of the form

$$U_k = k[X_{ik}; Y_{ik}(D)] \quad (B-14)$$

where

$$D = \sum_{j=1}^n Y_j$$

D stands for the extent of drug abuse as a social menace since Y_i by itself is not a sufficient reason for social concern. For the negative externality to have a social impact, it should be of such magnitude that alarms almost everybody. Thus D, the total amount of illicit drugs consumed by all drug-abusers and not just Y_i is the appropriate variable in k th's utility function.

Y_k now represents the amount of the i th good or service that the k th affected party must consume as a protective measure from anticipated bodily harm from drug-abusers. For example, Y_k may be in the form of increased police protection or security measure (which means additional taxes) and even weapons intended to ward off the lethal effluents of emitters. If the harm is inflicted, Y_k will include medical goods and services incurred by the k th affected party. Thus for the affected party, Y_k is of an imperative nature and represents the undesirable social problem of drug-abuse. Y_k increases as D increases but the marginal utility of Y_k to the k th party who may be inflicted the harm is negative so that the marginal damage or social cost of drug-abuse to the k th individual, MD_{D_k} , is

$$\frac{\partial U_k}{\partial D} = \frac{\partial U_k}{\partial Y_{ik}} \frac{\partial Y_{ik}}{\partial D} < 0 \quad (B-15)$$

The optimality condition that accounts for (B-15) is

$$MB_{Y_j} = P_{Y_j} + \sum_{k=1}^n MD_{D_k} \quad (B-16)$$

C. Output Effect of the External Diseconomy

1. Backlash Effect: (F→P→F) Type of Externality

Turning now to the important problem of the effect on output of the external diseconomy, it should be clear that the negative impact of the externality on output comes from its distortionary effect in production. In addition to this, the distortion in the relative prices of the inputs and outputs may also bring about changes in the commodity composition of total output.

Quite independently of the negative effect on the level and composition of total output that issues directly from the inefficiency arising from the external diseconomy, the disease, whether communicable or not, do have a well-known negative impact on the economy. This is the decrease in the productivity of the afflicted workers, or the withdrawal of these workers altogether from employment due to disability or even death. Important as this effect on the economy is, it is however unrelated to the output effect of the external diseconomy itself which results in the non-optimal allocation of resources, especially when production activity is involved in the externality. This can be clearly seen if all those who became ill are imagined to have completely recovered and regained their health and hence their productivity level before their affliction so that the previous level of output is restored. But the external diseconomy that results in the violation of the optimality conditions either in production or in consumption or in both

remains. If, however, in the $(F \rightarrow P)$ type of externality there is a negative backlash effect on production so that it becomes $(F \rightarrow P \rightarrow F)$, then the picture is entirely different since the reduction in the level of output occasioned by the external diseconomy can now be directly attributed to the externality itself. In other words, the effect of F as emitter on P backfires by affecting negatively the production function. To see this, consider the following equations:

$$Q_F = F(L, K), \quad F=1, 2, 3, \dots, P \quad (B-17)$$

$$E_j = [U_j(X_{ij}; Y_{ij})], \quad i, j=1, 2, 3, \dots, m \quad (B-18)$$

(B-17) is the production function of the F th firm, where L is labor and K is capital or any nonlabor input. As it stands, the production function is not yet affected by the externality.

(B-18) is the inverse function of the utility function in which work or labor is one of the independent variables. Alternatively, (B-18) may be interpreted as a version of the j th individual's supply of labor function where U_j is real income. As before, X_{ij} is the amount of the i th good or service while Y_{ij} is the amount of the i th medical good or service and represents the illness. The problem is to show the backlash effect of the external diseconomy on the production function. Since

$$L = \sum_{j=1}^m L_j \quad (B-19)$$

putting (B-18) in (B-19) and the result in (B-17), the production function becomes

$$Q_F^* = F[\sum_{j=1}^n L_j(U_j(X_{ij}; Y_{ij})), K] \quad (B-20)$$

from which

$$\partial Q_F^* / \partial Y_{ij} = \frac{\partial Q_F^*}{\partial L_j} \frac{\partial L_j}{\partial U_j} \frac{\partial U_j}{\partial Y_{ij}} < 0 \quad (B-21)$$

where the marginal product of the j th worker $\partial Q_F^* / \partial L_j$ is positive, and also

$$\partial L_j / \partial U_j > 0 \quad (B-22)$$

but as before,

$$\partial U_j / \partial Y_{ij} < 0 \quad (B-23)$$

(B-21) is interpreted as follows: The disease (external diseconomy) contracted by workers has an output-reducing effect in that it tends to depress marginal productivity through its negative effect on labor. This negative impact of the externality on the production function may be summarized by a coefficient b ($0 < b < 1$) so that measured in terms of efficiency units,

$$bL < L \quad (B-24)$$

From (B-18),

$$\partial L_j / \partial X_{ij} = \frac{\partial L_j}{\partial U_j} \frac{\partial U_j}{\partial X_{ij}} > 0 \quad (B-25)$$

and

$$\partial L_j / \partial Y_{ij} = \frac{\partial L_j}{\partial U_j} \frac{\partial U_j}{\partial Y_{ij}} < 0 \quad (B-26)$$

(B-26) means that the j th worker's supply of labor is being negatively affected by the illness Y_{ij} so that in terms of efficiency units labor supplied is less than what it would be without the negative externality.

Dividing (B-25) through by $\partial U_j / \partial X_{ij}$ gives (B-22), the unweighted marginal supply of labor.

Let the combination of (B-22) and (B-26) be positive, i.e.

$$\partial L_j / \partial U_j (1 - \partial U_j / \partial Y_{ij}) > 0$$

or,

$$(1 - \partial U_j / \partial Y_{ij}) > 0 \quad (B-27)$$

If the workers affected by the external diseconomy have not been completely disabled and continue to work despite their illness, (B-27) must be strictly positive and less than 1 to exclude values of $\partial U_j / \partial Y_{ij}$ which will make (B-27) meaningless.

Let $b = (1 - \partial U_j / \partial Y_{ij})$. Since in ordinal utility theory U_j is just an index, $\partial U_j / \partial Y_{ij}$ can be assigned to take on the maximum value of 1 so that $b = 0$. This is interpreted to mean that workers are completely incapacitated and unable to work or supply labor anymore so that L

vanishes from the production function - a virtually impossible situation. The other extreme is to have $\partial U_j / \partial Y_{ij} = 0$ so that $b = 1$. This means that U_j is independent of Y_{ij} , that is, there is no external diseconomy so that Y_{ij} should not be in the utility function - a situation that is irrelevant to the main objective of this study which is to depict diseases and bodily harm as external diseconomies. For these reasons, b must only be positive and less than 1. Applying b to (B-19), (B-24) is obtained. Thus b represents the negative effect of Y_{ij} on L . Letting $L^* = bL$, the production function of the firm (or firms) affected by the backlash of the external diseconomy is

$$Q_F^* = F(L^*, K) \quad (B-28)$$

If Q_F is F 's output level without the externality, then $Q_F > Q_F^*$ hence for all firms affected by the backlash, including non-emitters,

$$\sum_{F=1}^P (Q_F - Q_F^*) = \sum_{F=1}^P Q_F \quad (B-29)$$

is the decrease in output due to the fall in workers' productivity as a result of their illness.

With this result, the optimality condition that should account for the negative externality must now be reconsidered. Since the external diseconomy is a backlash on the original emitter F , then it is the optimality condition in (A-5) that needs to be amended. It should now be written as

$$MB_{Q_F} = MC_F + \sum_{j=1}^m MD_{Kj} + \sum_{F=1}^P Q_F \quad (B-30)$$

where social marginal cost, SMC_{Q_F} , is the right-hand side of (B-30).

2. P as Emitter, F as Affected Party: (P→F) Type of Externality

If, instead of the backlash effect in which the firm is the initial emitter and subsequent recipient of its own harmful emission, the emitter or emitters may be the people themselves as in the case of communicable diseases under the (P→P) type of external diseconomy so that the firm has no involvement but is adversely affected by the external diseconomy's negative impact on the productivity of its workers afflicted by the disease, then the type of externality is (P→F) instead of (F→P→F). Here the case just depicted and all its results ((B-17) to (B-29)) will still apply without any change but in this case, since P is now the emitter of the externality and F is the affected party, the optimality condition that should account for the external diseconomy is of the form

$$MB_{Qj} = P_Q + \sum_{F=1}^P MD_{jF} \quad (B-31)$$

III. Conclusion

It is not included in the objective of this paper to formulate appropriate regulatory and where the marginal damage inflicted by the jth individual to the Fth firm, MD_{jF} , is (B-21). Alternatively, the marginal damage may be expressed in terms of the decrease in the firm's (or firms') output or loss in revenue, i.e.

$$MB_{Qj} = P_Q + P_Q \sum_{F=1}^P Q_F$$

or

$$MB_{Q_j} = P_Q \left(1 + \sum_{F=1}^P Q_F \right) \quad (B-32)$$

where MB_{Q_j} is the marginal benefit that the j th consumer (or worker) derives from the firm's output Q_F , and P_Q is the price of Q_F so that $P_Q \sum_{F=1}^P Q_F$ is the value of output (F's revenue) lost due to the decrease in the productivity of the disease-afflicted workers of the affected firm (or firms).

A theoretical link between diseases (as external diseconomies) and the decrease in the level of output is thus provided. This concerns production cases in which external diseconomy is involved under the (F→P→F) type which depicts the backlash effect, and the (P→F) type which depicts the effect of any disease - communicable or not - emanating from the people themselves, on the production function.

III. Conclusion

It is not included in the objective of this paper to formulate appropriate regulatory and policy measures to check or correct the various cases of external diseconomies that have been presented. This problem properly belongs to normative economics, especially as it involves legal questions. But by way of concluding this study however, matters concerning property rights and the precise identification of the emitter - the locus of responsibility for the externality - shall be dealt with briefly. These matters or problems are important by themselves in that they may aid in the proper formulation of regulatory and policy measures.

It should be clear from the cases discussed under the types of external diseconomies considered that in the (P→P) type, the precise identification of the emitter is impossible especially in the cases of contagious diseases including hereditary diseases, and even the drug-abuse case which fall under other health and physical hazards form of external diseconomy. Under these circumstances and even if the mode of transmission of the disease (or diseases) is known as in the case of AIDS and drug-abuse externalities, the Coase theorem which hinges on the definition and enforcement of property rights has no relevance. In the first place, even if property rights can be defined as in the case of communicable diseases due to the unhygienic practices of people in depressed areas and improper waste disposal that pollute the environment in poor countries, exclusion is hardly possible short of uprooting entire communities of slum-dwellers. These conclusions emerge from the obvious nature (contagious diseases and bodily harm) and type (P→P) of the negative externality.

The only type of external diseconomy in which the emitter or locus of the responsibility maybe exactly identified and hence property rights maybe defined and enforced is the (F→P) or (F→P→F) type. But even in this, the mode of transmission of the externality may becloud the definition of property rights. For example, waterborne diseases can become airborne or soil-borne and vice-versa due to intermodal contamination. Hence the spatial coverage of the impact of the externality must be taken into account in addition to the mere definition of locationally limited property rights. This problem maybe clearly seen in the case when the external diseconomy has assumed epidemic proportion and is not just something that is confined or endemic to a particular place. Since these questions are beginning to encroach on legal and policy issues, it is perhaps appropriate at this point to leave the discussion on these problems

open-ended. The general conclusion that comes out of these however, is that there are clear types and cases of external diseconomies which do not involve property rights or in which the definition of property rights and its enforcement which is central to the Coase theorem may have limited relevance.

A. AIRBORNE

1. Telecommunication
2. Lapsing
3. Disasters
4. Whiskey & High
5. Bureaucracy
6. Superficial Neighboring Relations
7. Aircraft Noise Pollution
8. ...
9. ...
10. ...
11. Cases of the Inequality of Rights
12. ...
13. ...
14. ...
15. ...
16. ...
17. ...
18. ...
19. ...

B. WATERBORNE

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APPENDIX

MODE OF TRANSMISSION OF COMMON DISEASES²

A. AIRBORNE

1. Tuberculosis
2. Leprosy
3. Diphtheria
4. Whooping Cough
5. Bronchitis
6. Streptococcal Respiratory Infection
7. Meningococcal Infection
8. Smallpox
9. Chickenpox
10. Measles
11. Cancer of the Respiratory System
12. Leukemia
13. Emphysema
14. Meningitis
15. Pneumonia
16. Influenza
17. Some forms of Poisoning
18. Obstructive Pulmonary Diseases
19. Other Respiratory Diseases

B. WATERBORNE

1. Typhoid Fever
2. Salmonella Infections

3. Dysentery
4. Cholera
5. Bacterial Food Poisoning
6. Diarrhea
7. Viral Hepatitis
8. Malaria
9. Schistosomiasis
10. Dengue (Hemorrhagic) Fever
11. Filariasis (Elephantiasis)
12. Yellow Fever
13. Some forms of Food Poisoning
14. Other Infectious and Parasitic Diseases

C. SOILBORNE

1. Tetanus
2. Helminthiasis
3. Some forms of Food Poisoning

D. SEXUAL CONTACT

1. Acquired Immune Deficiency Syndrome (AIDS)
2. Syphilis
3. Gonorrhea

²The mode refers to the original source or form of transmission of the disease. Some diseases may, of course, be transmitted by a sequential combination of the various modes, e.g., the bacteria may first be waterborne and then airborne or soilborne, and vice-versa, due to intermodal contamination. It maybe noted that many of the diseases in the list are communicable.

REFERENCES

1. Bator, Francis M. "The Anatomy of Market Failure," Quarterly Journal of Economics. (August 1958).
2. Boadway, Robin W. and Wildasin, David E. Public Sector Economics. Second Edition. Toronto, Canada: Little, Brown and Company (Canada) Ltd. (1984).
3. Coase, Ronald H. "The Problem of Social Cost," Journal of Law and Economics. (October 1960).
4. Pigou, A.C. The Economics of Welfare. Fourth Edition. London: Macmillan & Co. Ltd. (1932).
5. Samuelson, Paul A. "Diagrammatic Exposition of a Theory of Public Expenditure," Review of Economics and Statistics. (November 1955).