THE ENVIRONMENTAL IMPACT OF ECONOMIC ACTIVITY

a multidisciplinary view

PETER VICTOR

The pin factory, about which Adam Smith wrote in 1776, [1] has served since then as an admirable example of the gains in productivity to be had from the division of labour. Although Smith was not writing about the activities of academics his analysis applies just as much to their world as to that of industry. Division of labour among academics has facilitated the extremely intensive study of many aspects of human behaviour and the physical environment in which it takes place. In terms of the increase in our knowledge of the Universe, this specialisation by academics has been highly productive indeed. It is something of a paradox, therefore, that the very process by which we gain knowledge should hinder and even prevent the solution to problems that our studies reveal.

I am referring, in the present context, to the 'problem of pollution' though I contend that the proposition contained in the above paragraph is generally applicable to the variety of phenomena which are considered to be the problems of the day. People from all sorts of disciplines have studied aspects of the pollution problem, but being aware of their own high degree of specialisation, there is a pronounced tendency for each to forgo offering general solutions to a problem which so obviously transcends any one academic discipline. The solutions that have been suggested are conspicuously narrow in their orientation so that engineers offer technical solutions, lawyers offer legal solutions, economists offer pricing solutions [2] and so on. What I hope to do in this paper is to present a framework within which contributions from at least four disciplines can be brought together and so provide the necessary holistic approach to the interactions of economic activity and the natural environment in which it is embedded.

Although the framework I intend to describe is an adaptation of a well known economic technique, it will become clear that the adaptation requires the replacement of the traditional economic approach to consumption and production by the approach taken by chemical engineers in particular, and physical scientists in general. It is because of this fundamental change in perspective that the model is not merely another economic model. The model is designed to show the technical possibilities open to a society, that is, the alternative patterns of consumption, and withdrawals from and discharges to the natural environment, which determine its quality. But, as political scientists are so eager to point out, technological constraints on the choices of a society are not the only constraints. The technical possibilities are limited, to one degree or another, by the institutions through which a society operates. It is for this reason that the political scientist can play a necessary role in defining the 'pollution problem', the solution to which is neither solely technical nor institutional, but some ill-defined combination of the two.

Having decried the limitations of other specialists who have worked on this topic, I am nevertheless obliged to emphasise economics, which is my own area of specialisation, to the neglect of all others. A case can be made for this, however, on the grounds that almost all sources of waste products, and many withdrawals from the environment, are the result of economic activities. These activities are classified by economists as either consumption or production. It may be surprising to non-economists that in analysing consumption and production economists have largely ignored their undesirable aspects. Even when attention is paid to, for example, the physical wastes created by producers or consumers there is an implication that these wastes are extraordinary. Unwanted wastes are generally referred to as 'externalities' and it is almost customary in much economic analysis to assume away externalities.

The problem goes deeper than this, however, since it is reflected in the economist's very conception of production and consumption. Production, according to economic theory, is an activity which turns inputs into outputs so that the market value of the outputs is greater than that of the inputs. (If this is not the case then the productive activity is unprofitable and will cease). Waste products, which do not have a market value, are ignored. In the case of production, even as seen by the economist, there is usually some physical output (the exception is the production of a pure service such as hairdressing), which is sold either to another producer, who uses it as an input, or to a final consumer. The same cannot be said of consumption. The activity of the consumer, which is what the analysis of demand is all about, is strangely conceived by the economist to be a process which turns commodities, which include both physical goods and services, into utility. Whatever utility is, and this has long been a topic of debate in welfare economics, it is not a physical entity.

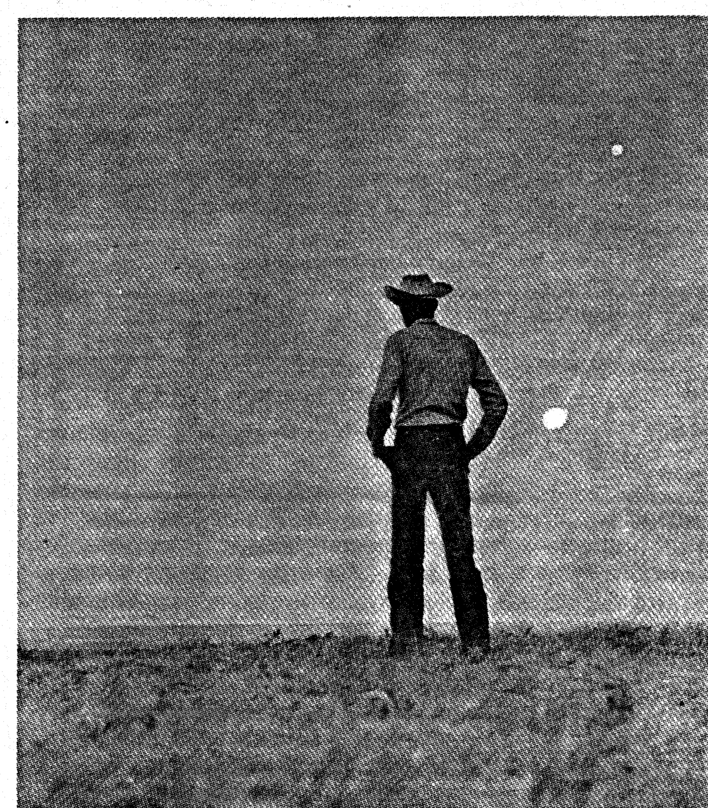
For some purposes, the economist's approach to production and consumption is very useful indeed. But for understanding the impact of economic activity on the natural environment, this approach is not helpful at all since it virtually ignores the aspects of these activities which are most important -- the unmarketed withdrawal of resources from the environment and the discharge of waste products back to the environment. It is at this point that the economist must look outside the confines of his own discipline to see how other scientists view these same activities of consumption and production. At a very general level, the pure scientist reminds us that matter cannot be created or destroyed, so that whatever happens to the matter that enters a production or consumption process, it is not destroyed. (I am deliberately neglecting the transformation of mass into energy and vice versa, since, except for the minute quantities of mass converted into energy by nuclear power plants, human activity which includes all economic behaviour, does not convert mass into energy or energy into mass). This physical law of the conservation of mass is embodied in the notion of a materials balance which is used by chemical engineers to describe productive processes.

Figure I (see Appendix) may be taken as a description of any economic process which requires physical inputs. Any production process uses some inputs which are purchased, and some which are withdrawn directly from the environment (for example the combustion of diesel fuel to drive a motor requires oxygen from the air). The motive power is then used to produce some marketable commodity, such as furniture, together with discharges of sulphur dioxide and wood chips.

Using Figure I to describe a consumption process, the input, say toothpaste, is discharged as some combination of liquid and solid waste. Figure I applies equally well to an entire economy. If it is the economy of a country then all purchases and sales are to people in other countries. If it is the economy of the world then no inputs and outputs are bought and sold. All inputs are 'free' and all outputs are discharges of waste. This world process has been aptly described as Spaceship Earth.

Before proceeding further, one important qualification is necessary. So far, no allowance has been made for the accumulation of matter in the economic system. Such accumulation may take the form of an increase in the physical stock of capital goods or inventories of finished and semi-finished goods. This is accumulation by firms. Accumulation by consumers may come as a change in the physical stock of consumer durables or in the stock of non-perishable commodities. Even waste products can be retained in a production process by recycling them through the process. However, this and the other forms of accumulation can only occur in something less than the very long run since eventually ashes really end up in ashes, and dust as dust. For the short run, which most of us are concerned with, accumulation is possible and can be allowed for by admitting it to the right-hand side of the materials balance equation of figure I. Thus, for any process, in less than the very long run, the mass of inputs must equal the mass of outputs plus any mass that is accumulated within the process.

The next step is to integrate the idea of materials balance into economic models of consumption and production. Rather than look at each consumption activity and each production activity in isolation by using partial analysis, a model which looks at all such activites simultaneously is needed if we are to assess the total im-



pact of economic activity on the environment. The method of input-output analysis is particularly relevant here since it has been designed, primarily, to analyse interdependence among industries and final consumers in an economy. [3] The fundamental idea upon which input-out analysis is based is that the inputs of one industry are the outputs of another and that, in general, all industries are interrelated by providing each other's inputs and using each other's outputs. Some outputs are also supplied to final consumers and it is this 'final demand' which is the driving force of an input-output model. Once the relations among the various industries have been established, that is, once estimates have been made of the input requirements per unit of output of each industry, an input-out model can be used to estimate the pattern and level of industrial activity necessary to produce a specified set of final demands. These inter-industry relations are usually estimated on the basis of data taken for a single, base year. The inputs and outputs of each industry for the base year may be used to estimate input-output coefficients, which are no more than statements of the input per unit of output for each industry.

An apple a day . . .

As DDT sales decline many farmers are turning to a product called parathion, manufactured by Monsanto, Stauffer, American Potash and Pennsalt. A recent Jack Anderson (syndicated) column reported on some of its harmful effects and its post-DDT sales growth spurt. We offer here some excerpts from the label on a container of the Pennsalt version, Parathion-25. The label was taken from a container used on part of last autumn's Washington State apple crop:

"Poisonous if swallowed, inhaled or absorbed through skin. Rapidly absorbed through skin -- repeated exposure may, without symptoms, be increasingly hazardous....

"Do not breathe powder, vapor or spray mist. Airplane pilots should wear full-face cannister-type mask....

"Burn or bury (used) containers, stay out of smoke; never re-use."

What about the rain from the sky that falls through the smoke from the burning of a container that once held the stuff?

Finally, "Call a physician immediately in all cases of suspected poisoning".

I'm calling mine.

Input-output analysis is more fully explained in the appendix to this paper. For the present it is sufficient to grasp the idea that industries are inter-related and that <u>the precise pattern and level of industrial activity in an economy depends largely upon what it is that the economy is called upon to produce</u>.* Once this is understood it is not difficult to see how input-output analysis may be extended to include the interdependence between the sectors of an economy and the environment which supports it. Just as each industry requires the outputs of other industries as inputs to produce its own output, each industry also requires inputs from the environment, such as air and water. Furthermore, each industry produces waste products as well as the economic outputs that it sells to other industries and final consumers. These wastes may be recycled through the production process or discharged to the environment. By regarding the environment as an additional industry in the input-output model and using data from a base year to estimate the environmental inputs and outputs per unit of industrial output, the input-out model may be used to estimate the impact on the environment of the industrial activity that is necessary to produce a specified pattern of final demands. This is explained in more detail in the appendix, but it is sufficient to understand that the entire procedure is merely a formalization of something that is very obvious. In order for consumption to take place, industries must produce. Industrial production requires inputs, some of which are merely the outputs of other industries, and some are drawn direct from the environment. Industrial production also produces waste products. An input-output model which explicitly includes the environment makes it possible to estimate firstly, the industrial activity that is necessary to produce the commodities people wish to consume and secondly, the impact that this activity has on the environment in terms of material taken from the environment and returned to it. In addition, the process of consumption itself requires inputs from the environment, (such as oxygen for the combustion of gasoline in motor-cars), and leads to the discharge of wastes back to the environment, (such as sulfur oxides emitted from motor-cars). These interactions may be estimate too, so that the complete model shows the impact on the environment of production <u>and</u> consumption. It will be observed that on the basis of the materials balance principle it is clear that if there is no accumulation of material within the economy then the mass of inputs from the environment must equal the mass of outputs discharged as waste products.

Insofar as consumption is the driving force of a market economy it is imperative if we are to understand pollution as a social phenomena, that consumption and pollution be linked in the kind of way that the modified input-output analysis described above allows. With this type of model it is possible to estimate the environmental impact of an economy when it is called upon to supply any pattern of goods and services that its members wish to consume. One study [4] has shown, for example, that to supply one dollar's worth of clothing at factory prices to Canadian households requires the use of 180.5 pounds of water of which 158 pounds is fresh and 22.5 pounds is brackish. Sulphur dioxide (0.05 pounds), carbon monoxide (.038 pounds) and sulphuric acid (0.00001 pounds) is produced in order to supply any one pound of clothing. It must be remembered, of course, that these estimates are not just the direct environmental inputs and waste products of the textile industry. They include the environmental inputs and waste products of those industries which supply commodities to the textile industry and also those of the industries which supply commodities to the industries which supply commodities to the textile industry and so on.

Enough has been said to show how input-output analysis can be used to analyse economic and environmental interactions. Appropriately adapted input-output models can be used to show the alternative patterns of household consumption and the use of environmental inputs and outputs (waste products) that are technologically feasible. We have already drawn on the physical sciences by making use of the concept of material balance. But these sciences have another contribution to make. The ecologists are the people who know most about the effects on the environment of the various waste products and the use of the environmental inputs. This type of information is required if we are to make a rational choice between consumer goods and environmental quality. The engineers can tell us what industrial processes might be altered and at what cost. This information allows us to modify the input-output models described above. Different technologies make different demands of the environment. It is only a lack of information which prevents us from integrating possible future methods of production into the input-output models.* To the extent that the engineers can provide this information it can be used in building models which will give us a more accurate picture of the technical alternatives open to us.

As was said earlier, technical constraints are not the only ones that are relevant. Institutional constraints must also be recognised and it is here that the insights of the political scientist are valuable. Although input-output models may be used to analyse any type of economic system which uses and produces commodities, the construction of a model for a particular economy, say that of Canada, incorporates implicitly, the present institutional structure of that economy. This institutional structure is very likely to impose limits of its own on the alternatives open to the society over and above those which can properly be described as technical. For example, it is possible to use the type of model we have presented to assess the impact on the environment of a transfer from private to public transportation. The possibility of making such a transfer may be limited by the political power of the corporations which manufacture automotive fuel and equipment.

This is but one facet of a much larger topic, the processes by which choices are made in our society. It is conventional to distinguish between market processes and political processes, the former studied by economists and the latter by political scientists, with very little overlap. This academic specialisation exaggerates the distinction between the two manifestations of power which are often directed towards similar ends and, for purposes of study, might be better dealt with under a general theory of economic and political choice. Nevertheless, for the present it suffices to examine each separately bearing in mind that people may be expected to pursue the easiest avenue to achieve a goal and this avenue will often involve economic and political action.

Looking at market behaviour first we see that economists emphasize the role of the individual who, as a consumer, determines how privately owned resources shall be employed, by bidding for products which require these resources as inputs in their manufacture. Information is transmitted from the consumer to the producer via the market. Advertising, insofar as it is a flow of *Information* in the opposite direction, is desirable since it enables consumers to make more informed market decision. But advertising is persuasive too and who can say whether an individual has made a better decision if he has been persuaded in his course of action, especially if the persuasion comes from someone who stands to gain directly from the particular decision that is made?

Some economists sing the praises of the market as a mechanism for registering individuals choices. Others, including myself, are more skeptical. An obvious weakness of the market is that it virtually ignores the effects of production and consumption on the parts of the natural environment which lie outside the jurisdiction of the private and public sectors of the economy. Put simply, one cannot buy clean air in a super-market. Only by staying away from the city can one avoid its dirty atmosphere, and that means of escape is becoming increasingly limited. If, as a society, we wish to have a cleaner environment and are prepared to forgo material wealth to get it we cannot express this choice via the market.

IT'S NOT MY BLACKENED LUNGS

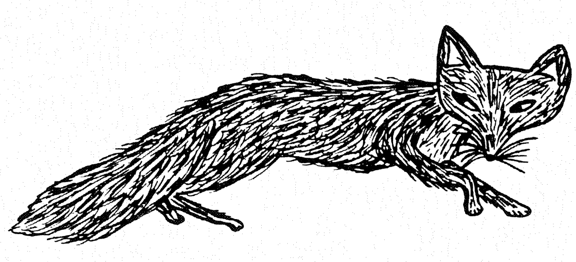
M.A. Denos

It's not my blackened lungs
THEMSELVES
(They can be replaced).
It's not my DDT blood
cells
Or the mercury bald spots
Which keep uniting
To extend my forehead.
It's not even my loss
Of hearing
Or breathing
Space
Or virility
Or natural
Beauty.
It's none of these things
(They all must have some kind of
Plastic substitute).
A man must make some
Compromises
For... progress...
And one could do worse
Than algae, picnicing on the
Astroturf.
It's the fact that
I'm slowly
In a million tiny ways
BEING
Systematically
Inevitably
MURDERED
That finally bothers me.

Or is it --
SUICIDE?

Two main options are open to us. As has been suggested by some economists[5] we can extend the scope of the market so that, in effect, people have a saleable right over air and water. This remedy may not be without use in special circumstances but, even then, it will not be implemented until more people have expressed their concern over environmental damage. Without more public support there is insufficient impetus for this type of legislated change. It is this apparent lack of widespread public support for a substantial rearrangement in our use of resources that leads us on to consider the second option we have for dealing with environmental problems. The political process is the other mechanism through which we express our desires as to how our society is to be regulated. Despite the existence of universal suffrage it would be naive (even for an economist) to suggest that political power is distributed equally among the members of the voting population. To a not insignificant degree, economic power implies political power. This may come from just knowing the 'right' people or, more obviously, it may be the quid pro quo one gets from contributions to party funds. The point is that people at the very top of the income and wealth scale are in a position to exercise an inordinate amount of political influence. Casual empiricism suggests that these people are unlikely to support policies directed towards pollution control at the expense of increases in gross national product. There are two reasons for this. Firstly, the richer one is the greater one's contribution to pollution control is likely to be. This is true whether the control is to be financed by tax revenue, by foregone business profits, or by a general decline in the rate of economic growth. Secondly, the very rich are the only members of the community who are unable to escape from most of the disamenities of pollution. They can live in remote areas which they reach by private plane or boat, and they can protect themselves from many of the unhealthy effects of pollution by buying their own air and water cleaning devices. And if their health does begin to suffer, the best medical treatment is at their disposal. In view of considerations such as these we cannot expect the richest members of society to wield very much of their political power in support of pollution control policies.

ECO-TACTIC No. 4



At the other end of the economic spectrum there are the poor and nearly poor, who, despite their poverty, possess considerable political power because of their large numbers. The distribution of income and wealth in Canada, and in all Western countries, is skewed so that 50 per cent of the population receive substantially less than 50 per cent of the total income (before and after tax), and own far less than 50 per cent of the total wealth. Nevertheless these people would be in a position to direct matters, if they were to act more or less in unison, though when it comes to pollution control it is not to be expected that concerted action from the lower income groups will provide a coherent anti-pollution drive for our society. The traditional lack of cohesiveness among the lower class is only one reason for this. The other is that low economic standing means that these persons value any increment to their income more highly than the same increment is valued by members of the middle and upper classes. It can be argued that it is in the private interest of the poorer members of the community to improve their situation by the acquisition of more material wealth almost irrespective of the environmental consequences of so doing. Even if the environmental circumstances are so bad that this course of action is not, in fact, in the best interests of poorer people, it is unlikely that these people will recognize such a situation. The obvious pressures of advertising and the less obvious forces through which we are socialized give powerful support to the acquisitive motives of us all. This is even more potent for those who are yet to acquire their first car, refrigerator and television.

Having argued that those people at both ends of the economic spectrum are unlikely to support vigorous (expensive) anti-pollution policies, I now turn to the third important group in the community -- the middle class. These people already possess substantial material wealth which normally includes a comfortable house fitted out with a variety of consumer durables. But members of the middle class are not wealthy enough to be able to buy themselves out of the society's pollution. This is the group which is prepared to forgo some addition to their material wealth in return for a cleaner environment. But this group does not have sufficient political power to effect such a change. Significant change of a type that will reduce the environmental damage of economic activity is only likely to happen if the 'active' middle class allies itself with either of the other two centres of political power -- the rich or the poor. As it becomes more and more expensive to avoid pollution by individual action, a greater number of high income earners may be expected to join the 'fight against pollution'. However, these newcomers to the cause will generally be the politically weakest members of the high income group purely because they are at the low end of the high income scale. Eventually, however, a large enough section of the very wealthy can be expected to align themselves with the middle class to reduce pollution as more and more high income earners consider that their income is no longer high enough to enable them to avoid the pollution that the rest of the community must face. It is not clear, however, that we have time to wait for the 'eventual'. In any case, it is far from clear what type of policies might be introduced under these circumstances, and much would depend on the precise way in which the situation develops.

However, I want to consider another option facing the middle class. Rather than wait until their ranks grow stronger with an influx of people from the top end of the income and wealth scale, the middle class anti-pollutionists might well attempt to arouse the interest of the low income earners and push through appropriate changes by sheer weight of aroused and organized numbers. To gain support from this section of the community something more than 'public education' will be required. Unless a possibility is generated whereby it becomes in the interest of the poor for society as a whole to give us some economic growth, it is foolhardy to expect the necessary input of political power to come from this group. What we are talking about is a redistribution of income and wealth on a scale that may well induce strong opposition from those who will be obliged to relinquish the privileged positions that they currently hold. Just how this might come about is unclear but it is a possibility which deserves our very serious consideration.

Perhaps I have strayed too far from the area of 'my' professional competence. This is for the reader to decide. I hope I have been able to offer some means of examining the alternatives open to society and to point to a few of the possible ways in which we may chose our environmental future.■

REFERENCES

1
Smith, A. *The Wealth of Nations* ed. E. Cannon (London: Methuen, 1901).

2
A sample of each of these types of solutions may be found in Kneese A.V. and Bower B.T. *Managing Water Quality, Economics, Technology and Institutions* (Baltimore: John Hopkins Press, 1968).

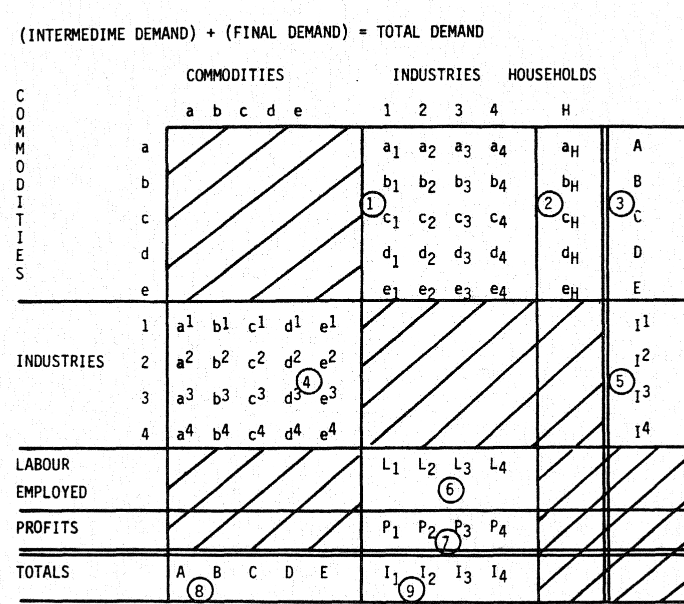
3
The ideas presented in this part of the paper are developed in full in the author's unpublished Ph.D. thesis, 'Input-output analysis and the Study of Environmental Interaction'. (U.B.C. April 1971.)

4
Ibid

5
See, for example, Dales, J.H. *Pollution, Property and Prices* (University of Toronto Press, 1968).

APPENDIX

This appendix is designed to show in some detail how input-output models may be used to analyse the impact of economic activity on the environment. First of all a simple input-output model will be described. It will then be extended to incorporate an environmental sector. (Appendix) Figure I is an input-output table for an economy which uses and produces five commodities: a, b, c, d, e. These commodities are produced by four industries: 1, 2, 3, 4 and consumed by households h, and also by the four industries. (For example, if commodity one is nails, then these nails are produced by the iron and steel industry, which also uses some of its own nails as well as selling them to other industries and to households.)



APPENDIX FIGURE I

Figure I is divided into 20 matrices of unequal size. Those that are shaded can be completely ignored, leaving only 9 to be explained. Entries are in dollar values. Matrix number 1 records the dollar value of each commodity unused by each industry, during a specified year. Thus a_1 shows the use of commodity a by industry 1, c_3 shows the use of commodity c by industry 3, and so on. Matrix 1 is a matrix of 'intermediate demands', since the commodities are demanded not for their own sake, but as inputs in the production of commodities to be consumed by households. Matrix 2 records the 'final demand' for each of the commodities. The total demand for each commodity, shown in matrix 3 is merely the horizontal summation of the intermediate and final demand for each commodity, so that $a_1 + a_2 + a_3 + a_4 + a_5 + a_h = A$ and so on. Matrix 4 records the output of each commodity by each industry: a^1 is

Readers' Inquiries

We invite readers to submit environment related inquiries. We will try to answer them or pass them on to our other readers through this column.

the output of commodity a by industry 1, d^4 *is the output of commodity d by industry 4. The aggregate output of each industry is displayed in matrix 5, where the entries are the horizontal summation of the rows of matrix 4:* $a^1 + b^1 + c^1 + d^1 + e^1 = I^1$ *and so on. The amount of labour employed in each industry is shown in matrix 6, where* I_1 *is the wage bill of industry 1. The profits of cash industry are recorded in matrix 7, where* p_1 *is the profits of industry 1. The total output of each commodity is shown in matrix 8 and is found by summing vertically the entries of matrix 4 so that* $a^1 + a^2 + a^3 + a^4 + a^5 = A$*.. The market values of the output of each industry is shown in matrix 9.* I^1 *the value of the output of industry 1 is equal to the cost of the inputs of the industry, including labour, plus the profits received by the industry. Thus,* $I^1 = a_1 + b_1 + c_1 + d_1 + e_1 + l_1 + p_1$*. The equivalent vertical summation of the columns of matrices 1, 6, and 7 give the entries of matrix 9.*

Two things should be very clear about the input-output table of figure I. First of all the input-output table describes a very simple economy. There is no government sector and no foreign trade, but these can be introduced without much trouble. The very small number of commodities and industries in the economy described by the table are of no real concern since these can be extended to include any desired number of commodities and industries. The second observation to be made about the table is that it is no more than a description of the economy to which it applies. It is a record of the use and production of commodities by industries and households, together with the employment of labour in the industries, all for a specific time period.

In order to transform the input-output data into an analytical model it is necessary to make some assumptions about the economic relation in the economy. The central idea is to link the consumption of the commodities by households to the activity of each industry. It may be assumed, for example, that each industry maintains a constant share of the market for each commodity supplied to households. This takes care of the final output of each commodity by each industry. On the input side it may be assumed

READERS' INFORMATION SERVICE

In this regular feature ALTERNATIVES offers suggestions on useful periodicals, conferences, events, and the like. We invite notices from readers. There is no charge, but space is limited and editorial discretion used.

1 There will be a 9-day Northern Wilderness Survival and Ecology Course in the Temagami area of Central Ontario. It will operate out from Camp Wanapitei beginning August 20 and again beginning September 10. Cost per person will be $60. Contact Beryl Mercer, 396 Downie St., Peterborough, Ontario.

2 The Journal (of the) Water Pollution Control Federation (3900 Wisconsin Ave., Washington, D.C. 20016) provides useful articles, reviews and news on the engineering, chemistry and biology of water pollution control.

3 The winners of Psychology Today magazine's excellent Dirty Pictures Art Contest (anti-pollution photographs, drawings, sculpture) will make a tour of art galleries and museums. We have reproduced several of the pieces in this issue of ALTERNATIVES, they all can be seen in November, 1970 Psychology Today. We will include the itinerary of the show in this column at a later date.

4 Environmental Quality Magazine is published by Environmental Awareness Associates, Inc., 6355 Topanga Canyon Blvd., Suite 327, Woodland Hills, California. They also publish Ecology News Briefs Newsletter. Write them for further information on both.

5 Canadian Water is a useful source of information on water management trends. It is available from 640 Seventh Avenue S.W., Calgary 2, Alberta.

6 The American Fisheries Society is a useful source of how pollution affects this vital resource. They publish a Newsletter and a scientific journal, Transactions of the American Fisheries Society. They are holding a conference in New York City, September 13-16. The organization's address is: Suite 1040, Washington Bldg., 15th and New York Ave.N.W., Washington, D.C., 20005.

that each industry uses its inputs of commodities and labour in fixed proportions. These two assumptions, one of constant market shares, and the other of fixed input proportions, are sufficient to link household consumption with industrial activity. Quite a different input-output model is achieved by replacing the constant market share assumption by the assumption that each industry produces commodities in fixed proportion. It is an empirical question to be decided by prediction as to which input-output model best describes a particular economy.

This is not the place to debate the merits and demerits of alternative input-output models. The above discussion is only a sketch of what is indeed a very intricate and difficult matter. All that is hoped for here is that the basic idea of input-output models be understood so that we can turn our attention to the use of these models in analysing the impact of an economy on the environment. Such analyses require that the environment be introduced into the input-output table, as shown in appendix figure II.

	COMMODITIES a b c d e	INDUSTRIES 1 2 3 4	HOUSEHOLDS H	TOTAL DEMANDS	WASTE PRODUCTS W N M O
a		INPUTS OF COMMODITIES TO INDUSTRIES	PURCHASE OF COMMODITIES BY HOUSEHOLDS	A	
b				B	
c				C	
d				D	
e				E	
1	OUTPUT OF COMMODITIES BY INDUSTRIES			I^1	W^1 N^1 M^1 O^1
2				I^2	W^2 N^2 M^2 O^2 (10)
3				I^3	W^3 N^3 M^3 O^3
4				I^4	W^4 N^4 M^4 O^4
LABOUR EMPLOYED		L_1 L_2 L_3 L_4			
PROFITS		P_1 P_2 P_3 P_4			
TOTALS	A B C D E	I_1 I_2 I_3 I_4			W N M O (11)
W		W_1 W_2 W_3 W_4		W	
X		X_1 X_2 X_3 X_4		X (13)	
Y		Y_1 Y_2 Y_3 Y_4 (12)		Y	

APPENDIX FIGURE II

Figure II is the same as Figure I with the addition of 3 'environmental inputs' W, X and Y, and 4 waste products, W, N, M and O, all of which are measured in tons-weight. Matrix 10 shows the output of each waste produced by each industry so that W^1 is the output of W by industry 1. The total output of each waste product, shown in Matrix 11, is found by summing vertically the columns of matrix 10, hence $W^1 + W^2 + W^3 + W^4 = W$. The entries in matrix 12 show the use of the environmental inputs by each industry, where X_2 is the amount of X used by industry 2. The total use of each environmental input, recorded in matrix 13, is equal to the horizontal summation of the rows of matrix 12, so that $W_1 + W_2 + W_3 + W_4 = W$. If there is no accumulation of matter within the economic system during the time period to which the input-output table applies, say via a change in capital stocks or inventories of finished and semi-finished goods, then the mass of environmental inputs used by industry must equal the mass of environmental outputs discharged by industry plus the mass of material that ends up as consumer goods. This materials balance is expressed by the equation:-

$$W + X + Y + = W + N + M + O + N$$

where N is the mass of consumer goods produced in the relevant time period.

It will be noted that W appears as an environmental input and also as a waste product. An example of this is water used for cooling industrial boilers, later discharged as waste. The other point to notice is that no allowance is made in the input-output table for the waste products of households nor their use of environmental inputs. These have been omitted for purposes of exposition but could be included with little difficulty.

As before, some assumptions relating the data in the input-output table are necessary for constructing an analytical model. Again a variety of assumptions are available, each leading to different models. Perhaps the simplest assumptions are that the environmental inputs and waste products are used and produced by each industry in fixed proportions. With these assumptions it is possible to predict the effect of changes in the pattern of the marketed out-puts of industries on the environmental impact of those industries. And since we have already shown how the household demands can be related to the industry outputs it is possible to link these household demands with the associated environmental inputs and waste products used and produced by industries in order to meet those household demands.■

Reader-participant anti-waste campaign

All unnecessary use of material and energy resources can clearly be considered environmentally unsound. Obviously defining unnecessary in this context is a problem -- but we don't have to trouble over it here as there are sufficient obvious cases available amidst the glut of our continent.

To give readers an idea of what sort of thing we have in mind, ALTERNATIVES has begun a modest inquiry into the production of licence plates. Many provinces and states make 5-year plates and send out little stickers in the intervening years. But Ontario produces annually a new set of two plates for each car in the province. Assuming that there are 10 licence plates to the pound, that is roughly 1,200,000 pounds of metal wasted each 5-year period (most ending up in the dump). More important is a nearly equally massive amount of paint (the manufacture of which produces wastes containing lead) and a considerable amount of heat and other energy (which, unless it is derived directly from wind or sun is likely to involve considerable environmental damage in one form or another). Both the paint and the energy would be used even if the plates were turned in for recycling.

In our next issue we will provide a list of provinces and states which engage in this wasteful practice and, perhaps, some brief replies from them to our objections. We welcome suggestions and help from our readers.