What IMPLAN Can and Can't Do For You

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Notes:

1) It can't be stressed enough that these are my own personal comments, and my responsibility is total for any errors, expressions of opinion, or anything else herein. Neither KEEE nor Yeshiva University nor any other individual or group has any responsibility or liability for any material contained in this document.

2) This discussion will be seen as hostile to ABB and the other people who have prepared the LTER regarding the Maryland Renewables Porfolio Standard (RPS), if my experience with Professor Richard Green of the University of London in the IAEE Energy Forum in 2012 (and others) is any guide. That is not my intent. In many ways, I think what they have done is exemplary, and it is just a matter of trying to explain what they have done and look at it, not a contest in humiliating one another.

I. Input-Output Analysis

IMPLAN is a commercial package that provides input-output analysis for the United States as a whole, for individual states, or for municipalities. There are relatively few commercial entities that provide such analysis anywhere in the world. IMPLAN is unique in its level of detail, and its attempt to keep the detail relevant and modern.

Input-output analysis was originally developed by Wassily Leontief in 1936. In the discussion below, I will refer to William Miernyk, *The Elements of Input-Output Analysis* (New York: Random House, 1965) and Ronald E. Miller and Peter Blair, *Elements of Input-Output Analysis, Foundations and Extensions*, 2nd Edition (Cambridge: Cambridge University Press, 2009) as my references for discussing it. In discussing IMPLAN, reference should also be made to a most helpful web link

https://implanhelp.zendesk.com/hc/en-us/articles/115009505587-Key-Assumptions-of-IMPLAN-Input-Output-Analysis

Many of these comments will be taken directly from this source, although some history will be added.

Who originally used input-output analysis, and why has it come to be relatively rare? The original users were largely government organizations. They were trying to get a sense of how much materials and labor and other items would be required for specific projects. In the U.S., by the late 1990s, the two organizations that had maintained input-output tables of any sort were the U.S. Department of Commerce, and the U.S. Department of Agriculture. (The comments made about the Forestry Service being the agency with the U.S. Department of Agriculture that maintained the input-output tables during the November 2018 online session were accurate.) It is my understanding, which could be wrong, that the Department of Commerce input-output model is the basis for other types of input-output modeling, which have advantages and drawbacks of their own. See

http://www.ilw.com/seminars/JohnNeillCitation.pdf

and

https://cefa.fsu.edu/sites/g/files/imported/storage/original/application/18d780904fc532b3cf0bcdcc8a082bfa.pdf

The Departments of Commerce and Agriculture ceased to develop their tables as public references during the 2000s, when it was decided that it was not in the public interest to spend the money, and the work was privatized.

The coefficients for IMPLAN or any other input-output table are usually obtained for a specific year. Here, I will take the example used in the Miernyk book as an illustration of what is going on. In this example, just so people have an intuitive idea of what is going on, I will ignore gross inventory depletion (although this would be very relevant in the computations), gross inventory accumulation, depreciation, imports, payments to government, investment in fixed capital (gross private capital formation), government purchases, and exports. For our purposes, the only input households will supply will be labor. Households will be the only consumers as well. All these other items can be added back in. All figures will be in billions of dollars.

Suppose we have 5 industries, A, B, C, D, E, and F, and households. Industry A sells 10 billion dollars of items to itself in order to produce. But industry A doesn't only purchase from itself. It purchases from B, C, D, E and F, and it purchases labor from households. Similarly, B buys from itself, but it purchases from A, C, D, E, and F and households. We can write up a table for all the industries involved, as Mierynk has done. Here, H will indicate households.

Excerpt from Miernyk's Table

Inputs\Outputs	A	B	C	D	E	F	H	Total Output
A	10	15	1	2	5	6	14	53
B	5	4	7	1	3	8	17	45
C	7	2	8	1	5	3	5	31
D	11	1	2	8	6	4	4	36
E	4	0	1	14	3	2	9	33
F	2	6	7	6	2	6	8	37
H	19	23	7	5	9	12	1	76
Total Outlays	58	51	33	37	33	41	58	311

For example, industry A buys 11 billion dollars from industry D. Industry C sells 5 billion dollars to industry E. To find the amount of industry purchases from one industry by another, locate the *purchasing industry* at the top of the table, then read *down the column* until you come to the *purchasing industry*. To find the amount of sales from one industry to another, locate the *selling industry* along the left side of the table, then read across the row until you come to the *buying industry* (Mierynk, *op. cit.*, 11).

Industries buy labor, and the labor supplied is in *row* H. Industry B buys 23 billion dollars' worth of labor.

But industries also must sell. The way things are set up here, the only final purchasers are individual consumers. The purchases of individual consumers are in *column* H. Industry F sells 8 billion dollars to consumers.

This is still not an input-output table, but it is close. We now ask, "What are the amounts of inputs required from each industry to produce one dollar's worth of the output of a given industry?" These are the technical coefficients. They can be expressed in physical units (quantities of coal per ton of steel), or dollar units (dollars of coal per one dollar's worth of steel). Unless I am severely mistaken, I believe all modern input-output tables (of any magnitude) are derived in dollar units. The coefficients are for the processing sector industries only.

How do you get the coefficients? You divide by the numbers of the far right column, "Total Output", for each entry. Here, household labor will also be included as an entry. We will leave column H out of this division, for reasons which will become clear shortly, and will leave "Total Outlays" out, too.

The resulting table is as follows:

Modified Technical Coefficients from Mierynk's Table

Inputs\Outputs	A	B	C	D	E	F
A	0.19	0.28	0.02	0.04	0.09	0.11
B	0.11	0.09	0.16	0.02	0.07	0.18
C	0.23	0.06	0.26	0.03	0.16	0.10
D	0.31	0.03	0.06	0.22	0.17	0.11
E	0.12	0.00	0.03	0.42	0.09	0.06
F	0.05	0.16	0.19	0.16	0.05	0.16
H	0.25	0.70	0.21	0.15	0.27	0.36

This is saying that it takes 2 cents from industry C to produce one dollar of industry A's output, and so forth.

Now, we introduce matrix notation, which is crucial for the solution to the problem. Suppose we call the matrix, the table of coefficients that has just been produced, *A*. (Here, the italics are being introduced to avoid confusion, which otherwise will ensue, quite easily, in my experience.) Matrix *A* has 7 rows. They are denoted by A, B, C, D, E, F and H, but in general, they are referred to by numbers. The first number denotes the row, the second the column. So, using numbers, *A*(2,3) = 0.16. This is the entry in the 2nd row and the 3^{rd} column, and it says industry C needs 16 cents of industry B's output to produce 1 dollars' worth of output.

Suppose we denote the final outputs we want, for consumers, as *vector* X. This is a matrix of 1 column. In our original case, the outputs were given by the column under H, with rows 14, 17 … 8, 1. In the original case, it took total requirements 53, 46 … 37, 76. Suppose in general that we call our requirements *vector* Y. Assuming we can scale up and down as we need (this is an assumption, which will be described shortly), then the general problem can be described as

*A**X = Y

This is matrix multiplication. If our vector X were

5

6

7

4

3

2

this would start off 0.19*5 + 0.28*6 + 0.02*7 + 0.04*4 + 0.09*3 + 0.11*2 = our first row element of Y.

This matrix equation has a general solution. (I will not go into detail about when this solution exists; for the sake of argument, for all the cases we are interested in, we will assume the solution exists.) Suppose we define the identity matrix I as a matrix which has 1's along the first diagonal and 0's everywhere else. For this case, it is

Six by Six Identity Matrix

1	0	0	0	0	0
0	1	0	0	0	0
0	0	1	0	0	0
0	0	0	1	0	0
0	0	0	0	1	0
0	0	0	0	0	1

Suppose we denote an inverse matrix as M^{-1} for matrix M. Then $M*M^{-1} = I$. We allow matrix subtraction and addition, in which corresponding elements of two matrices of the same size and shape can be subtracted or added. The general solution to this problem is thus

$(I - A)^{-1}*Y = X$

This general solution is what IMPLAN is providing. Inverting a 536 by 536 matrix is not a trivial operation.

Now the general features of the renewable portfolio standard can be described. The *assumed* total spending that we will need to get 25% of Maryland electricity to be generated from renewable sources is Y. We want to get X. IMPLAN provides, within limits, *A*, and inverts the matrix solution as above.

There are certain aspects that are worth noting, which is why IMPLAN is relatively unique. First, to consider the bottom row of Total Outlays in the original matrix. This *should* add up to the same thing as the final column. Here it does not, because not all the items in the Mierynk matrix are being put in. In the original source, (Miernyk, *op. cit.*, 9), these two sets of figures do add up to each other.

In general national or income accounting or regional accounting, such a difference is known as a statistical discrepancy, and is by no means simple to resolve. Here's a real case. Suppose we have 10 numbers, such as $3,000, $6,400, $200, $800, etc. The sum of these numbers must add up to $24,000, and the sum must consist of 4 numbers out of the 10. *Only one* combination is correct. The number of combinations of 4 items from a set of 10 is

$\frac{10!}{4!*6!} = (10*9*8*7)/(4*3*2) = 10*9*7/3 = 10*3*7 = 210$

If each combination takes 1 minute to check, this is 3½ hours just for one item in the worst case. So IMPLAN is doing a lot of work to avoid this problem.

The assumptions for IMPLAN can now be seen clearly. The scaling characteristic requires constant returns to scale, so that for all cases, if we double outputs, we double inputs. We must not have bottlenecks, so no particular input can run out. Similarly, technology is assumed not to change, so the *A* matrix remains a relevant guide. The other assumptions of the implanhelp link above are all necessary for the scaling assumption to be maintained and be useful.

Taxes and or tariffs can be put in IMPLAN, but are not trivial, and do require the same sort of static assumptions. For what IMPLAN can do with taxes, see

https://implanhelp.zendesk.com/hc/en-us/articles/115009674528-Generation-and-Interpretation-of-IMPLAN-s-Tax-Impact-Report

A very optimistic view of how a carbon tax would work (for Mexico) using the general approach, is in

http://iopscience.iop.org/article/10.1088/1748-9326/aa80ed/pdf

Any changes in taxes would have to be forecasted and imposed by the user. Without going into details, it would be wise for carbon tax advocates to study the example of Australia, in which those penalized by the carbon tax found the most effective use for adjustment allowances to try cope with the tax was to spend them on changing the government that imposed it. A balanced look at Australia's experience is in

https://www.centreforpublicimpact.org/case-study/carbon-tax-australia/

IMPLAN has no mechanism for going into these political aspects.

What IMPLAN can do with tariffs is discussed in

http://blog.implan.com/taxes-and-tariffs

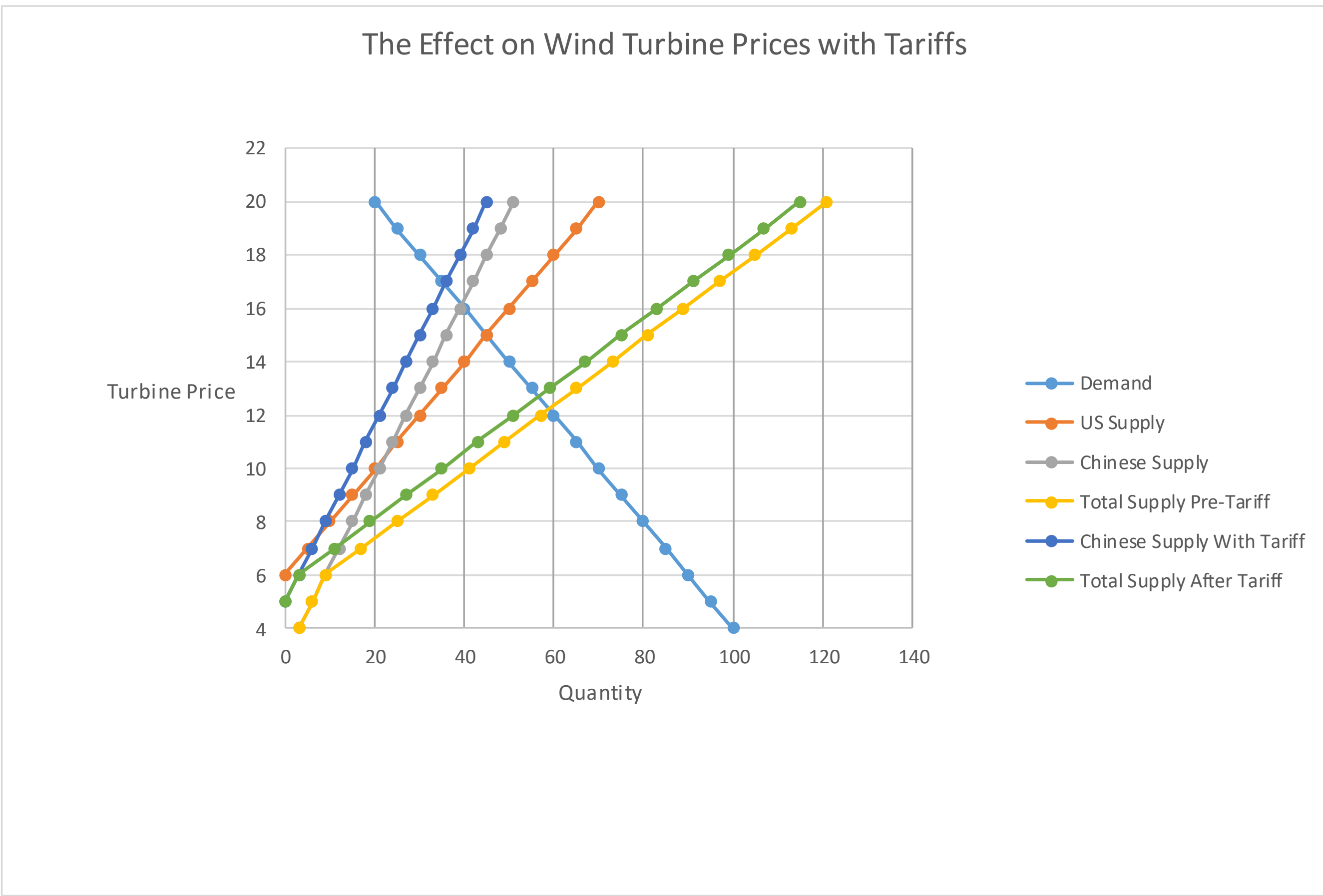
Basically, the effect of tariffs as it relates to the renewable portfolio standard is to increase the expense in purchasing items that would be necessary for the renewable providers to operate, and thus increasing the coefficients in the table above. The Chinese company Goldwind is a major supplier of wind turbines, see

https://en.wikipedia.org/wiki/Goldwind

and

https://www.windpowermonthly.com/goldwind

A possible description of how this could happen is in the graph below.



The supply for turbines is made of U.S. manufacture and Chinese manfacture (Goldwind). This ignores European manufacture, which makes up part of the American market. Before the tariffs are imposed, total supply, the horizontal sum of American and Chinese manufacture, has a kink at a price of 6, and total supply (denoted by the yellow line) intersects the total market demand at a price near 12. After the tariffs, Chinese supply is forced to the left, and there is still a kink at 6, but it is closer to the origin. Total market supply moves up to the green line, with an intersection of total demand near the price of 13. Quantities purchased in a free market fall, and the distribution between utility supply and distributed supply, and more especially imports, may move to reflect this. To have an accurate forecast of the effect of the tariffs, we would thus need to know when they would be imposed, how long they would last, whether they would change, both U.S. and Chinese supply and Maryland demand. IMPLAN will not supply any of this, but can respond once assumed changes are made.

Finally, there is presumably a benefit from the RPS in terms of health. But this also must be imposed from the outside. A simple example can show this. IMPLAN sector 472 is "472 Elementary and secondary schools" spending. IMPLAN sector 482 is "482 Hospitals". Suppose the RPS lowers time parents have to spend taking children away from school to cope with the asthma attacks of the children. This change would lower the labor price to achieve given outputs if the parents were working, and could be imposed exogenously. It would be quite likely to raise educational spending, which would require exogenous adding as well. But educational achievement as translated into later labor productivity for what are now young children would not be counted, and would have to be discounted back. The tangible cut now would be the reduction of hospital spending and spending on other medical care items such as "477 Offices of other health practitioners" and "475 Offices of physicians". IMPLAN could conceivably count the reductions in the medical spending, but would register them as a reduction in value from the RPS. Any benefits from the increased productivity would have to be imposed from outside the model.