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Letters to the Editor

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LETTERS TO THE EDITOR

Dear Sir:

In my article "Communication Networks in Intermediate Markets", *Management Science*, IV (January, 1958) the statements on page 158 concerning a condition of symmetry in the communication network require amendment. Equation (6) contains the ratio $r/r + 1$, where r is the ratio of the number of supplying firms to the number of customer firms. It is stated that $r/r + 1 \leqq \frac{1}{2}$. This is of course true only if the number of supplying firms is less than or equal to the number of customer firms. While this added restriction holds for many market structures, it is by no means universal, and the condition of symmetry stated in equation (6) should, accordingly, be applied only to markets where the fact is that $s \leqq c$.

Also, on page 160, signs should be reversed on two second derivatives in order that they match both common sense and the written text:

$$\frac{d^2M}{dW^2} < 0 \quad \text{should be} \quad \frac{d^2M}{dW^2} < 0;$$

and $f''(W) > 0$ should be $f''(W) < 0$.

Yours truly,
F. E. BALDERSTON
University of California
Berkeley

Dear Sir:

Comments on Orchard-Hays, Wm., "Evolution of Linear Programming Computing Techniques," *Management Science*, Vol. 4, pp. 183–190, (Jan. 1958).

Recently we completed a transportation program using the method described by Ford and Fulkerson, *Management Science*, Vol. 3, pp. 24–32, (Oct. 1956). We can handle problems up to size 20 × 120 with this code. The program was written for the Datatron, an intermediate size computer, whose basic execution times are 2.5, 10.8, and 14.0 milliseconds for addition, multiplication, and division respectively. The following table is typical of the running times achieved. The terminology breakthrough and non-breakthrough is fully discussed in Ford and Fulkerson's paper.

Size	Number Breakthroughs	Number Non-breakthroughs	Time in Minutes Total—Calculation Only
7 × 35	21	6	11–6.5
20 × 20	21	9	19–9
20 × 100	42	2	53–23

Presuming the times quoted by Orchard-Hays are for programs using "The Stepping Stone Method" or variants thereof, it would seem that the solution described by Ford and Fulkerson is much more efficient. The UNIVAC time of 6 hours for a 14 × 120 problem seems excessive in comparison.

This whole matter of reporting the time of computer runs deserves more attention. Hand computation of only a few transportation problems should be convincing evidence that problem structure is an important factor to consider. By problem structure I have reference to the distribution of supply, to the distribution of demand, and above all, to the distribution of the matrix elements. In our typical applications the ratio of the number of unique elements to the total number of elements was low, approximately one-tenth. This fact has an important bearing not only on computer time, but even more basic on the choice of method and the manner of translating the method to machine language. In view of such considerations, the size of the problem, the number of iterations, and the computer used without reference to its basic speed is not enough information to evaluate any given computer procedure.

The efficiency of our program depends to a great extent upon the use of a normalization (scale) command, similar to the Store and Count command on the IBM 650. Some computers such as the IBM 704 or 709 do not have a normalization command. This loss is deplorable in view of the high degree of sophisticated programming required to solve large-scale transportation problems efficiently.

Our experience on the Datatron using the original LP simplex method with minor modifications has been successful. Our average production problems run from sizes 20 × 34 to 38 × 42 with times from 15 minutes to an hour. The arithmetic is 8-digit floating decimal point. In order to run larger problems after the acquisition of magnetic tape units, whose basic speed is 46 milliseconds per block of 20 words, we now have a program which offers the following features, which compare favorably with the "last word" 704 program.

Maximum number of restraints plus non-basis vectors: 1000
Arithmetic: 8-digit floating decimal point.
Automatic translation of input data to particular problem formats.
Revised simplex method, product form of inverse.
Infeasibilities automatically eliminated.
Parametric LP for a right hand side given as a linear vector function of a scalar parameter.
Special indicators to allow suboptimums to be computed over any selected set of vectors.
Restart at any iteration with any change in the set of vectors one wishes.
Restart without computation loss on magnetic tape read failures.

The largest problem we have run with this program was of size 108 × 184. The problem ran for 240 iterations in 43.5 hours. Suboptimums were computed first over nearly independent sets of vectors before the computer was turned loose on the full problem. Our main interest in running this problem was to see if we could obtain a useful solution with 8-digit floating decimal point arith-

metic. Our final results were accurate to five-plus significant digits, which is quite adequate for our purposes.

Very truly yours,
BRUCE P. PRICE
Computing Department
Operations Analysis Division
Phillips Petroleum Company
Bartlesville, Oklahoma

Dear Sir:

In reply to Mr. Price, his points on solving the transportation problem are well taken. The time of 6 hours on the Univac which I mentioned was excessive and was reduced drastically by a more careful choice of starting solution. Ford and Fulkerson's method is undoubtedly more efficient and it is certainly worthwhile to have a computer program for it. But Phillips Datatron program itself must have required a "high degree of sophisticated programming." It is very doubtful that any machine program can be designed to take advantage of special features of all problems such as can be done by hand. As to machine features, since the IBM 704 and 709 have floating point arithmetic, the lack of a normalization command hardly seems "deplorable." There are certainly other more serious lacks.

With regard to the Datatron program described for the general LP problem, it appears to be a very fine piece of work and the problem times seem about right when one considers the relative speeds of the Datatron and the 704. I can assure Mr. Price, however, that he very likely will encounter problems with 100-odd restraints in which 8-digit floating point will not be sufficient. Even if it is, the time for running a 100 by 900 problem, which his code will accept, will likely be prohibitive. The 704 codes could easily be modified to accept 511 restraints but, again, running times would be very high. One doubts the wisdom of providing facilities which are overly expensive to use. How often can a Datatron installation allot 43.5 hours to one LP problem, especially when the same problem could be run in one to $\frac{1}{2}$ hours on a 704 without obtaining sub-optima?

I hope the experience of Mr. Price and others in this problem area will someday persuade computer manufacturers to take these problems into consideration in the machine design stage. There is a limit to what one can do with programming and analysis. A few simple but carefully planned machine instructions and an adequate tape system could reduce running times drastically.

Very truly yours,
WILLIAM ORCHARD-HAYS
Director, Computer Services Division
Corporation for Economic and
Industrial Research
1200 Jefferson Davis Highway
Arlington 2, Virginia