Integer Programming

Recall that we defined integer programming problems in our discussion of the Divisibility Assumption in Section 3.1. Simply stated, an *integer programming problem* (IP) is an LP in which some or all of the variables are required to be non-negative integers.*

In this chapter (as for LPs in Chapter 3), we find that many real-life situations may be formulated as IPs. Unfortunately, we will also see that IPs are usually much harder to solve than LPs.

In Section 9.1, we begin with necessary definitions and some introductory comments about IPs. In Section 9.2, we explain how to formulate integer programming models. We also discuss how to solve IPs on the computer with LINDO, LINGO, and Excel Solver. In Sections 9.3–9.8, we discuss other methods used to solve IPs.

9.1 Introduction to Integer Programming

An IP in which all variables are required to be integers is called a **pure integer programming problem.** For example,

$$\begin{aligned} \max z &= 3x_1 + 2x_2 \\ \text{s.t.} \quad & x_1 + x_2 \le 6 \\ & x_1, x_2 \ge 0,\ x_1, x_2 \text{ integer} \end{aligned} \tag{1}$$

is a pure integer programming problem.

An IP in which only some of the variables are required to be integers is called a **mixed integer programming problem.** For example,

$$\begin{aligned} \max z &= 3x_1 + 2x_2 \\ \text{s.t.} \quad & x_1 + x_2 \le 6 \\ & x_1, x_2 \ge 0,\ x_1 \text{ integer} \end{aligned}$$

is a mixed integer programming problem (x_2 is not required to be an integer).

An integer programming problem in which all the variables must equal 0 or 1 is called a 0–1 IP. In Section 9.2, we see that 0–1 IPs occur in surprisingly many situations.† The following is an example of a 0–1 IP:

$$\begin{aligned} \max z &= x_1 - x_2 \\ \text{s.t.} \quad & x_1 + 2x_2 \le 2 \\ & 2x_1 - x_2 \le 1 \\ & x_1, x_2 = 0 \text{ or } 1 \end{aligned} \tag{2}$$

Solution procedures especially designed for 0–1 IPs are discussed in Section 9.7.

*A nonlinear integer programming problem is an optimization problem in which either the objective function or the left-hand side of some of the constraints are nonlinear functions and some or all of the variables must be integers. Such problems may be solved with LINGO or Excel Solver.

†Actually, any pure IP can be reformulated as an equivalent 0–1 IP (Section 9.7).

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