Chapter 2
Disaggregation of Stocks

Logic is the muse of thought. When I violate it I am erratic; if I hate it, I am licentious or dissolute; if I love it, I am free—the highest blessing the austere muse can give.

C. J. Keyser, *Mathematical Philosophy*, 1922, p. 136

2.1 Promotion Within the Firm

In the previous chapter, we modeled the dynamics of a fish population living in a pond. We implicitly assumed that all fish are born at a reproductive age and leave the pond irrespective of their age. If you were operating a fishery at your pond, you may want to selectively remove fish of different age classes to maximize your revenues. This may help you to capitalize on differentials in the reproductive rates of younger and older fish and the fact that rates of reproduction are higher at lower densities. A model of the different age cohorts in your pond would require that you disaggregate the stock FISH into the different age classes and introduce age-specific reproduction and extraction rates.

Let us take up this idea of disaggregating stocks into subgroups of individuals here to model the dynamics of a company that consists of assistants, directors, and executives. Each of these three groups makes up part of your "company stock." You are put in charge of personnel in that company and are given the task of changing the distribution of people among the three positions in the company hierarchy from the current distribution to a desired one. Currently there are 800 assistants, 100 directors, and 10 executives. People get hired into the company at the assistant level, some of the assistants get promoted to become directors, and some of the directors ascent to become executives. People retire from the company after they

A save-disabled version of STELLA® and the computer models of this book are available at www.iseesystems.com/modelingeconomicsystems.

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reached the executive position. The desired company hierarchy is one with 900 assistants, 90 directors and 9 executives.

To achieve the desired company hierarchy, you need to hire and promote people at the appropriate rates. Assume that it is easier for you to hire new assistants than promote assistants to directors or directors to executives. Assume also that the rate of retirement is beyond your influence. The hiring rate is 100% of the difference between the actual and desired number of assistants. The rates at which you can promote assistants to directors and directors to executives are 80 and 60%, respectively. The retirement rate is 5%. Can you achieve the desired distribution for the company hierarchy within 10 years? Let us set up the STELLA model to answer this question.

Define three state variables as stocks, one each for ASSISTANTS, DIRECTORS, and EXECUTIVES. Model an inflow of HIRES into the stock of ASSISTANTS and outflows of ASSISTANTS into the stock of DIRECTORS and from DIRECTORS to EXECUTIVES. PROMOTION of ASSISTANTS to DIRECTORS is a function of the desired and actual stock and of the rate at which you can hire people into the company. The DESIRED ASSISTANTS and HIRING RATE are exogenously given parameters that you should specify as transforming variables—they will transform the flow of hires. This flow is

$$\text{HIRE} = \text{HIRING RATE}\ ^{*}\ (\text{DESIRED ASSISTANTS} - \text{ASSISTANTS}). \quad (2.1)$$

The larger is the difference between the number of desired and actual assistants, the more new assistants are hired. Similarly, we can define

$$\text{PROMOTION} = \text{PROMOTION RATE}\ ^{*}\ (\text{DESIRED DIRECTORS} - \text{DIRECTORS}), \quad (2.2)$$

$$\text{ASCENSION} = \text{ASCENSION RATE}\ ^{*}\ (\text{DESIRED EXECUTIVES} - \text{EXECUTIVES}), \quad (2.3)$$

$$\text{RETIRMENT} = \text{RETIREMENT RATE}\ ^{*}\ \text{EXECUTIVES}. \quad (2.4)$$

The STELLA model is shown in Fig. 2.1.

Make an educated guess on the dynamics of the company hierarchy and then run the model over 20 years to see whether you guessed correctly and whether you can achieve the desired goals by year 10. The results are shown in Fig. 2.2.

The goal of having 900 assistants is soon achieved, but there are more directors and fewer executives than desired. Decrease the rate for promotion of assistants to directors and see whether this should help you reach the goal. What are the effects on the number of executives? Can you adjust the ascension rate to reach the desired number of executives? Where is the bottleneck in your company hierarchy, and how can you solve the problem of achieving the desired structure within 10 years? Set up the model to show, over time, the size of the male and female work force. To do this, assume different hiring, promotion and ascension, and retirement rates for the two groups of employees. Then, investigate the time it would take to have an

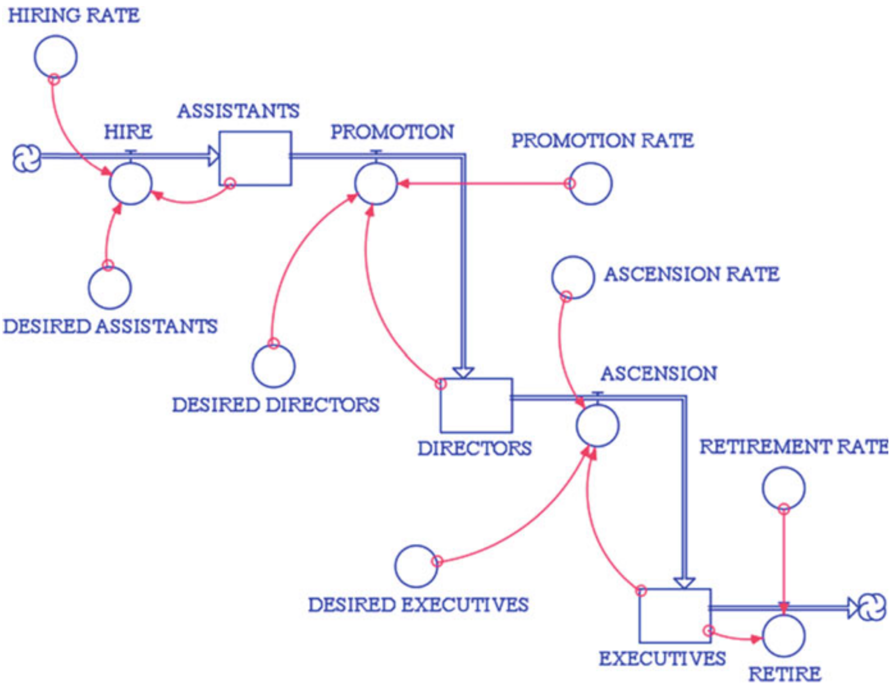

Fig. 2.1 Company hierarchy model

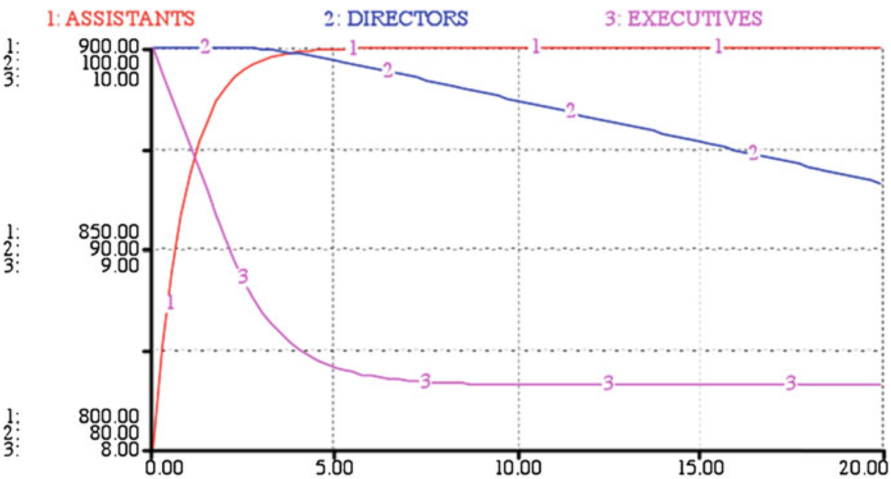

Fig. 2.2 Company hierarchy

equal share of each gender in the company. What are the implications of your findings for your personnel planning?

In this model, we have expanded on the logic of the previous chapter by tracing, for exogenously given parameters, the effects of inflows to and outflows from stocks on a system's dynamics. We have then noted the influence of the parameters on the system's state variables over time. We have disaggregated a single stock of employees into subgroups based on their positions in the company hierarchy, because treating the entire work force of the company as a single stock would not have enabled us to answer the question of optimal hiring strategies. The resolution at which we model the system depends on the question we wish to answer. The following chapter will illustrate this point in more detail. There we proceed in the opposite direction. Rather than disaggregating a system of interest into ever-smaller parts, we increasingly add to the model parts of the system's surroundings.

2.2 Disaggregated Stocks Model Equations

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ASSISTANTS(t) = ASSISTANTS(t - dt) + (HIRE - PROMOTION) * dt
INIT ASSISTANTS = 800
INFLOWS:
HIRE = (DESIRED_ASSISTANTS-ASSISTANTS)*HIRING_RATE
OUTFLOWS:
PROMOTION = (DESIRED_DIRECTORS-DIRECTORS)*PROMOTION_RATE

DIRECTORS(t) = DIRECTORS(t - dt) + (PROMOTION - ASCENSION) * dt
INIT DIRECTORS = 100
INFLOWS:
PROMOTION = (DESIRED_DIRECTORS-DIRECTORS)*PROMOTION_RATE
OUTFLOWS:
ASCENSION = (DESIRED_EXECUTIVES-EXECUTIVES)*ASCENSION_RATE

EXECUTIVES(t) = EXECUTIVES(t - dt) + (ASCENSION - RETIRE) * dt
INIT EXECUTIVES = 10
INFLOWS:
ASCENSION = (DESIRED_EXECUTIVES-EXECUTIVES)*ASCENSION_RATE
OUTFLOWS:
RETIRE = EXECUTIVES*RETIREMENT_RATE

ASCENSION_RATE = .6
DESIRED_ASSISTANTS = 900
DESIRED_DIRECTORS = 90
DESIRED_EXECUTIVES = 9
HIRING_RATE = 1
PROMOTION_RATE = .8
RETIREMENT_RATE = .05
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