Copy the text of the assignment from the web site.
Refer to the following pages for the models you are copying and experimenting with.

2.2 Formulation: The BSNSS2 Model

The model formulation sections in this book show how the urban processes identified in the verbal description sections can be described by model equations and discuss additional aspects of the real processes in the context of specific equations. The verbal descriptions furnish the overall picture of the system; the formulation sections fill in the details of modeling. However, the successive formulation sections discuss only the model equations that either have not appeared in or have been changed from earlier models. A full set of the equations for each model appears in the equation listings in the text and in the respective model listings in the chapter appendixes.

Flow Diagram. Figure 2-2 is a flow diagram that gives a pictorial representation of the interrelationships between the variables in the BSNSS2 model. In principle, the flow diagram resembles the flow diagrams of other types of computer programs. Each outlined symbol corresponds to the equation defining the specified variable. For example, the rectangle represents the level of business structures BS. The arrow adjacent to the level symbol represents a flow into the level. The stylized valve symbol that crosses the flow arrow gives the name of the rate—business construction BC. The cloud symbol at the end of the arrow indicates that the elements that make up the flow rate—the men, materials, and money that come together to create business structures—originate outside the system being modeled. The dotted lines that point toward the rate symbol represent the information flows that are the inputs to the rate equation.
Section 2.2

Figure 2-2 DYNAMO flow diagram

Information flows run from business structures BS, business construction normal BCN, and the business-land multiplier BLM.

The business-land multiplier BLM and the land fraction occupied LFO, which appear inside circles, are auxiliary variables. Auxiliaries clarify the meaning of the equations by separately representing different processes in the system. For example, the land fraction occupied LFO gives land occupancy as a function of the number of business structures BS. LFO is then used in the equation for BLM to compute an influence on the construction rate. Business construction BC could have been expressed in one single equation that depended only on the constants and on business structures BS, but the auxiliaries allow one to see the chain of cause-and-effect relationships represented in the model.

The flow diagram is an intermediate step between a causal-loop diagram and the actual model equations. The flow diagram shows the structure of the loops in the system (the positive loop connecting business structures BS and business construction BC, and the loop connecting business structures BS, the land fraction occupied LFO, the business-land multiplier BLM, and business construction BC). The flow diagram also shows the variables and constants used in each equation, which usually do not appear in a causal-loop diagram. To gain familiarity with the flow diagram’s symbols and to see the connection between each equation and the remainder of the system, the reader may wish to refer back to the flow diagram as the text describes the equations.

Equation 1 defines the level of business structures BS, which was discussed in Section 1.4 (equation 1 of the BSNSS1 model).

<table>
<thead>
<tr>
<th>BS.K=BS.J+DT*BS.JK</th>
<th>BS=BSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS</td>
<td>BSN=1000</td>
</tr>
<tr>
<td>1, L</td>
<td>1, J, N</td>
</tr>
</tbody>
</table>
Chapter Two: The BSNSS2 Model

(Note that each equation will now be presented in a format that lists the equation number and equation type to the right of the equation, not on the left as in the original BSNSS1 computer program.)

Business Construction BC. Equation 2 defines the rate of business construction BC, which differs from the formulation in the BSNSS1 model: a third term, the business-land multiplier BLM, has been introduced. When BLM equals 1.0, business construction BC is exactly the product of business structures BS and business construction normal BCN, as in the BSNSS1 model. When the business-land multiplier BLM rises above 1.0 it stimulates construction; when BLM sinks below 1.0 it reduces construction below what it would have been without the influence of land.

\[
\text{BC} = \text{BS} \times \text{BCN} \times \text{BLM}
\]

Modulating rates of flow with multiplicative factors is often a convenient and realistic representation of the influence of one variable on another. This multiplicative format is discussed in more detail in Section 5.3.

Business-Land Multiplier BLM. Equation 3 defines the business-land multiplier BLM, an auxiliary variable that reflects the influence of land occupancy on business construction BC. Land occupancy is quantified in the model by the land fraction occupied LFO, which varies between zero for unoccupied land and 1.0 for fully occupied land. The equation for the business-land multiplier BLM is not expressed with arithmetic operations. Instead, the equation instructs the computer to look up the value of BLM in a table. Figure 2-3 is a graph of the BLM table. At small values of LFO (representing sparse land occupancy), the graph indicates that increasing land occupancy tends to increase business construction due to the richer infrastructure implied by the denser development. As the land fraction occupied LFO increases past 0.4 (40 percent), however, the business-land multiplier BLM decreases with increasing LFO. The decrease in BLM represents the inhibiting effects on business construction of rising land prices and diminishing choices of location.

\[
\text{BLM} = \text{TABLE}(\text{BLMT} + \text{LFO})
\]

The word TABLE in the equation instructs the computer to look up a value in a table. BLMT (business-land multiplier table) tells the computer the name of
Chapter Two: The BSNSS2 Model

(Note that each equation will now be presented in a format that lists the equation number and equation type to the right of the equation, not on the left as in the original BSNSS1 computer program.)

Business Construction BC. Equation 2 defines the rate of business construction BC, which differs from the formulation in the BSNSS1 model: a third term, the business-land multiplier BLM, has been introduced. When BLM equals 1.0, business construction BC is exactly the product of business structures BS and business construction normal BCN, as in the BSNSS1 model. When the business-land multiplier BLM rises above 1.0 it stimulates construction; when BLM sinks below 1.0 it reduces construction below what it would have been without the influence of land.

\[
BC = BS \times BCN \times BLM
\]

Where:
- BC - BUSINESS CONSTRUCTION (UNITS/YEAR)
- BS - BUSINESS STRUCTURES (UNITS)
- BCN - BUSINESS CONSTRUCTION NORMAL (FRACTION/YEAR)
- BLM - BUSINESS-LAND MULTIPLIER (DIMENSIONLESS)

Modulating rates of flow with multiplicative factors is often a convenient and realistic representation of the influence of one variable on another. This multiplicative format is discussed in more detail in Section 5.3.

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\[
BLM = \text{TAB}\text{E}\text{(BLMT+LFO.K+0.1)}
\]

Where:
- BLM - BUSINESS-LAND MULTIPLIER (DIMENSIONLESS)
- BLMT - BUSINESS-LAND MULTIPLIER TABLE
- LFO - LAND FRACTION OCCUPIED (FRACTION)

The word TABLE in the equation instructs the computer to look up a value in a table. BLMT (business-land multiplier table) tells the computer the name of
the table in which to find the values. LFO.K is the input to the table. Since the table cannot contain all possible values for LFO and the corresponding values for BLM, the table specifies a finite number of points, and the computer assumes that the graph is a straight line between the points, as shown in Figure 2-3. The zero following LFO.K in the equation indicates that the first number in the table gives a value of BLM for LFO equal to zero. Similarly, the number 1 in the equation indicates that the last number in the table gives a value of BLM for LFO equal to 1.0. Finally, the number 0.1 indicates that the table gives values for BLM for every 0.1 increment in the value of LFO. The equation for BLM might be expressed in English as, “Find the value of BLM by looking in a TABLE named BLMT. That table specifies values for BLM, beginning with LFO equal to zero and ending with LFO equal to 1.0, at intervals in LFO of 0.1.”

The business-land multiplier table BLMT gives a broad-brush representation of the effects of land availability on business construction. The development of infrastructure, diversity of choice, and land prices have no explicit input to BLM. Instead, they are implicit in the table function BLMT that relates BLM to the land fraction occupied LFO. The BSNSS2 model could have been formulated to represent infrastructure and land prices explicitly. However, such a degree of explicit detail is not necessary, nor even desirable, for present purposes. The BSNSS2 model is intended to provide a fundamental explanation of urban behavior rather than a microscopic view of the urban land market. The business-land multiplier table BLMT expresses the minimum information needed to model the effects of land occupancy on business construction.

*Land Fraction Occupied LFO.* Equation 4 quantifies land occupancy as the fraction of the total land area currently occupied by buildings. The product of business structures BS and land per business structure LBS gives the land area in
acres currently occupied by buildings. Dividing the land area occupied by the total AREA gives the land fraction occupied LFO.

<table>
<thead>
<tr>
<th>LFO.K=BS.K*LBSS/AREA</th>
<th>AREA=1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBS=0.2</td>
<td>4.1, C</td>
</tr>
<tr>
<td>LFO</td>
<td>4.2, C</td>
</tr>
<tr>
<td>BS</td>
<td>A</td>
</tr>
<tr>
<td>LBS</td>
<td>C</td>
</tr>
<tr>
<td>AREA</td>
<td>C</td>
</tr>
</tbody>
</table>

The BSNSS2 model contains several parameters whose constant values characterize the system being modeled: the business construction normal BCN, the business-land multiplier table BLMT, the land per business structure LBS, and the AREA. These parameters constrain and define the meaning of several model variables. For example, the value of land per business structure LBS defines a business structure BS as a structural unit that occupies an average of 0.2 acres of land. The value of business construction normal BCN defines another characteristic of business structures BS: the businesses within the structures, through various processes, engender new construction in the amount of 7 percent per year of the present number of business structures.

The parameter values in a model should specify a consistent description of the system being modeled. If chosen improperly, the values may characterize events or entities that have no real counterpart. For example, the business-land multiplier table BLMT slopes upward for low values of land fraction occupied LFO, reflecting the stimulating effect of infrastructure development on business construction. However, if the area being modeled is very small, the sewers, roads, schools, stores, restaurants, and services available within the area would not be very important in determining business construction if those facilities were available just outside the area. An upward-sloping BLMT is appropriate only in combination with a fairly large AREA; both BLMT and AREA must be chosen to represent a single real system.

![Figure 2-4](The BSNSS2 model: reference behavior)
Section 5.1  Verbal Description  113

5.1 Verbal Description: Interactions between Jobs and Labor Force

Urban residents are not self-sufficient. They have neither sufficient land for producing food nor sufficient knowledge and raw materials to make their own clothing and shelter. An urban resident must depend on a source of income to obtain money for food, clothing, and shelter. Jobs and such job-surrogate income sources as savings, pensions, social security, welfare, and unemployment insurance are the principal means of support for an urban population.

Because most people depend upon jobs to support themselves and their families, the availability of jobs and the promise of higher incomes are prime motivations for moving. People tend to move away from areas where jobs are relatively unavailable to areas where employment opportunities are greater. Television news, newspaper stories, advertisements, word-of-mouth accounts from friends and relatives, and industrial recruiting—all tend to create perceptions of higher wages and greater opportunities in labor-short areas and of relatively unfavorable job conditions in labor-surplus areas. As perceptions of relative job opportunities among individual cities change over time, more people tend to migrate to cities perceived to offer relatively more job opportunities and to move away from cities perceived to offer relatively fewer job opportunities. This book uses jobs in a highly aggregated sense to include all employment related to the production or maintenance of individual or social wealth. Therefore, buildings used by such diverse sectors of the urban economy as government, service, transportation, and education are all considered to provide business jobs.

When people move into or out of an area they add to or subtract from the number of people in the area’s labor force. Because labor is a necessary input for most business activity, businesses cannot ignore the availability of labor in their location and expansion decisions. Readily available labor allows businesses greater flexibility in choosing employees and shortens the time necessary to find qualified persons to fill specific positions. Moreover, high labor availability tends to decrease wage competition for labor among businesses.

The preceding verbal description identifies the cause-and-effect relationships that couple an urban population to an urban economic base. These cause-and-effect relationships form two feedback loops that interconnect through a measure of local employment conditions—a labor-force-to-job ratio—as shown in Figure 5-1. The labor-force-to-job ratio is simply the number of workers in the labor force divided by the number of jobs available. This ratio aggregates such measures of job-market conditions as unemployment, job openings, labor force skills, promotions, overtime, and wages. A value exceeding 1.0 means that there are more workers than jobs, indicating relatively unfavorable employment conditions. However, the ratio cannot indicate whether the unfavorable conditions are low wages, layoffs, slow promotions, or reduced hiring. When the value of the labor-force-to-job ratio is less than 1.0, relatively favorable employment conditions are indicated.
Chapter Five: The POPBSN Model

The top loop in Figure 5-1, a negative loop, modulates the rate of population growth in response to the availability of jobs. When jobs are plentiful (indicated by a value of the labor-force-to-job ratio greater than 1.0), in-migration swells the area's population. The labor force expands with the population, which reduces the job surplus. The bottom loop in Figure 5-1, also a negative loop, modulates the rate of economic expansion in response to the availability of labor. When labor is plentiful and cheap (indicated by a value of the labor-force-to-job ratio less than 1.0), businesses tend to locate or expand within the area, increasing both the rate of business construction and the number of business structures. The resulting increase in the number of jobs reduces the labor surplus. Conversely, when labor is scarce and expensive, businesses tend to locate elsewhere, reducing the rate of business construction and the number of excess jobs available, so the labor shortage is diminished.
5.2 Formulation: The POPBSN Model

The flow diagram in Figure 5-2 shows two levels in the POPBSN model: population P and business structures BS. These two levels are interconnected through the two feedback loops described in Section 5.1. Both feedback loops share a common variable, the labor-force-to-job ratio LFJR, which influences the rates controlling both levels. A land-constraint feedback loop, first developed in the BSNSS2 model, limits the growth of the system.

Equations 1 through 3 define population P, births B, and deaths D, respectively. They were discussed in Section 4.2—equations 1 through 3 of the POP1 model.

\[
\]

\[
P = PN
\]

\[
PN = 50000
\]

\[
P = POPULATION (PERSONS)
\]

\[
B = BIRTHS (PERSONS/YEAR)
\]

\[
IM = IN-MIGRATION (PERSONS/YEAR)
\]

\[
D = DEATHS (PERSONS/YEAR)
\]

\[
DN = OUT-MIGRATION (PERSONS/YEAR)
\]

\[
PN = POPULATION INITIAL (PERSONS)
\]

\[
B, KL = P, KL * BN
\]

\[
BN = 0.03
\]

\[
B = BIRTHS (PERSONS/YEAR)
\]

\[
P = POPULATION (PERSONS)
\]

\[
BN = BIRTHS NORMAL (FRACTION/YEAR)
\]

\[
B, KL = P, KL * DN
\]

\[
DN = 0.015
\]

\[
D = DEATHS (PERSONS/YEAR)
\]

\[
P = POPULATION (PERSONS)
\]

\[
BN = DEATHS NORMAL (FRACTION/YEAR)
\]

In-migration IM. As in equation 4 of the POP2 model (Section 4.3), the rate of in-migration IM in the POPBSN model depends upon both in-migration normal IMN and an attractiveness multiplier. In the POPBSN model, the single measure of urban attractiveness for migration is job availability, represented in equation 4 by the attractiveness-of-jobs multiplier AJM.

\[
IM, KL = P, KL * IMN * AJM, K
\]

\[
IMN = 0.1
\]

\[
IM = IN-MIGRATION (PERSONS/YEAR)
\]

\[
P = POPULATION (PERSONS)
\]

\[
IMN = IN-MIGRATION NORMAL (FRACTION/YEAR)
\]

\[
AJM = ATTRACTIVENESS-OF-JOBS MULTIPLIER (DIMENSIONLESS)
\]

For simplicity, employment conditions influence only the rate of in-migration IM, although in reality employment conditions can influence both in-migration
Figure 5-2 The POPBSN model: DYNAMO flow diagram
Section 5.2

and out-migration. In-migration normal IMN remains at 10 percent per year as in the earlier POP1 and POP2 models.

Equations 5 and 6 define out-migration OM and percentage population growth PPG, respectively, which were discussed in Section 4.2 (equations 5 and 6 of the POP1 model).

\[
\begin{align*}
\text{OM, XL}= & P \times PMN \\
\text{PMN}= & 0.07 \\
\text{OM}= & \text{OUT-MIGRATION (PERSONS/YEAR)} \\
P= & \text{POPULATION (PERSONS)} \\
\text{PMN}= & \text{OUT-MIGRATION NORMAL (FRACTION/YEAR)} \\
\text{PPG, K}= & (B \times JK + IM \times JK - JK - OM \times JK) / P \times K \\
B= & \text{BIRTHS (PERSONS/YEAR)} \\
\text{IM}= & \text{IN-MIGRATION (PERSONS/YEAR)} \\
D= & \text{DEATHS (PERSONS/YEAR)} \\
\text{OM}= & \text{OUT-MIGRATION (PERSONS/YEAR)} \\
P= & \text{POPULATION (PERSONS)} \\
\end{align*}
\]

*Attractiveness-of-Jobs Multiplier AJM.* The attractiveness-of-jobs multiplier AJM in equation 7 modulates the rate of in-migration IM in response to the employment conditions, represented by the labor-force-to-job ratio LFJR.

\[
\begin{align*}
\text{AJM, K}= & \text{TABLE(AJM, LFJR, K, 0.2, 2)} \\
\text{AJM}= & 2.1/1.95/1.8/1.6/1.35/1.5/1.3/1.2/1.1/1.0/1.0 \\
\text{AJM}= & \text{ATTRACTION-OF-JOBS MULTIPLIER (DIMENSIONLESS)} \\
\text{AJMT}= & \text{ATTRACTION-OF-JOBS MULTIPLIER TABLE} \\
\text{LFJR}= & \text{LABOR-FORCE-TO-JOB RATIO (PERSONS/JOB)} \\
\end{align*}
\]

A value of LFJR less than 1.0 indicates such auspicious employment conditions as high wages, easy access to jobs, and rapid promotion. Under these favorable conditions, the attractiveness-of-jobs multiplier AJM rises above 1.0 and stimulates the rate of in-migration IM. At the extreme left of the attractiveness-of-jobs multiplier table AJMT (Figure 5-3), where the value of the labor-force-to-job ratio LFJR approaches zero, the curve is nearly flat. The saturating curve represents the hypothesis that small changes in extremely favorable employment conditions do not substantially alter the impact of high job availability on an urban area’s attractiveness. In the center of the AJMT curve, where the labor-force-to-job ratio LFJR equals 1.0, employment conditions within the area are normal, and the attractiveness-of-jobs multiplier AJM also equals 1.0. When AJM equals 1.0, the normal rate of migration into the area, as determined by the product of population P and in-migration normal IMN in equation 4, is neither restricted nor augmented. (Section 5.3 has a more extensive discussion of the meaning and function of normal values.) The right side of the attractiveness-of-jobs multiplier table AJMT depicts unfavorable employment conditions, which may include low wages, low job availability, layoffs, or lack of promotions. At the extreme right, the curve represents the hypothesis that, when the labor-force-to-job ratio LFJR climbs to 2.0 or higher, job conditions are so bad that almost no one moves into the area. AJM falls almost to zero.
Equation 8 defines the level of business structures BS, which was discussed in Section 3.2 (equation 1 of the BSNSS3 model).

\[ BS.K = BS.JK \cdot (BC.JK - BD.JK) \]

\[ BS = BSN \]
\[ BSN = 1500 \]

- BS = BUSINESS STRUCTURES (UNITS)
- BC = BUSINESS CONSTRUCTION (UNITS/YEAR)
- BD = BUSINESS DEMOLITION (UNITS/YEAR)
- BSN = BUSINESS STRUCTURES INITIAL (UNITS)

**Business Construction BC.** The form of the equation for business construction BC (equation 9) remains the same as in equation 2 of the BSNSS2 model presented in Section 2.2, although the multiplier now responds to different inputs.

\[ BC.KL = BS.K \cdot BCN \cdot BCM.K \]

\[ BCN = 0.07 \]

- BC = BUSINESS CONSTRUCTION (UNITS/YEAR)
- BS = BUSINESS STRUCTURES (UNITS)
- BCM = BUSINESS CONSTRUCTION NORMAL (FRACTION/YEAR)
- BCM = BUSINESS-CONSTRUCTION MULTIPLIER (DIMENSIONLESS)

**Business-Construction Multiplier BCM.** Business construction BC should respond not only to land availability but also to labor availability. Consequently, the business-construction multiplier BCM is defined in equation 10 as the product of two other multipliers, the business-land multiplier BLM and the business-labor-force multiplier BLM.
Section 5.2  

Equations 11 and 12 define the business-land multiplier BLM and the land fraction occupied LFO, respectively, which were discussed in Section 2.2 (equations 3 and 4 of the BSNSS2 model).

Equation 13 defines the rate of business demolition BD. (See equation 6 of the BSNSS3 model in Section 3.2.)

Business-Labor-Force Multiplier BLFM. Equation 14 defines the business-labor-force multiplier BLFM, which represents the impact of labor availability on business decisions to locate in, or expand in, an urban area. The availability of labor is represented by the labor-force-to-job ratio LFJR.

When the labor-force-to-job ratio LFJR equals 1.0, employment conditions are normal and the business-labor-force multiplier BLFM has a value of 1.0. At a value of 1.0, business construction BC proceeds at the normal rate, equal to the product of business structures BS and business-construction normal BCN (equation 9). The upward-sloping curve in Figure 5-4 indicates that a high labor availability generally stimulates construction. The business-labor-force multiplier BLFM does not go to zero in the absence of a labor force (labor-force-to-job ratio LFJR equals zero); a nonzero multiplier represents the assumption that people will come to fill jobs if the jobs are available.

Large labor surpluses (indicated by a labor-force-to-job ratio LFJR much greater than 1.0) have two conflicting effects on business construction. One is a
result of supply-and-demand conditions in the labor market: with labor in excess, positions are quickly filled, and wage competition among businesses for employees is minimized. The other effect of a labor surplus on business construction stems from the influence of a high rate of unemployment on skill levels, attitudes toward work, and neighborhood quality—all of which tend to be eroded by continued high unemployment. Persistent high unemployment can discourage business expansion within the area. High training costs, rapid employee turnover, theft, and vandalism deter further economic growth. The business-labor-force multiplier table BLFMT therefore levels off when the labor-force-to-job ratio LFJR reaches 2.0. When LFJR equals or exceeds 2.0, any further availability of labor fails to stimulate business expansion because of the negative effects of a labor surplus.

Labor-Force-to-Job Ratio LFJR. As described in Section 5.1, the labor-force-to-job ratio LFJR represents a surrogate measure of many aspects of internal employment conditions. Dividing the number of persons in the labor force LF by the number of jobs J in business structures gives the labor-force-to-job ratio LFJR (equation 15).

\[ LFJR = \frac{LF}{J} \]

An LFJR value greater than 1.0 indicates unfavorable employment conditions (a surplus of labor over jobs) relative to normal conditions. Inversely, a value less
than 1.0 indicates favorable employment conditions relative to a normal period. In this book, the normal period and normal conditions are defined as the conditions prevailing in the late stages of an urban area's growth phase, when the area's economy is still fundamentally healthy and jobs are usually available.

The labor force LF and jobs J are defined below, respectively, as the employees available and the employment that would be offered under conditions defined as normal. When employment conditions are not normal, the labor force LF may not correspond precisely to the actual number of people seeking work, and jobs J may not correspond precisely to the actual number of employment positions in the urban area. Consequently, the labor-force-to-job ratio LFJR bears no simple quantitative relationship to actual unemployment rates. As noted, unemployment is only one possible symptom of unfavorable employment conditions; other possible manifestations of unfavorable employment conditions include low wages, reduced overtime, a lack of promotions, slow hiring rates, and layoffs.

In the POPBSN model, equation 1.2 gives the value of population initial PN as 50000, and equation 8.2 gives business structures initial BSN as 1000. At the start of the simulation of the model, the labor-force-to-job ratio LFJR equals 17500/18000, a value slightly less than 1.0. A value of LFJR less than 1.0 corresponds to an abundance of job opportunities and a labor shortage, conditions often encountered in rapidly growing urban areas.

**Labor Force LF.** Since not everyone in an urban area works, the labor force LF is defined in equation 16 as the fraction (the labor-participation fraction LPF) of the population P that would seek or hold jobs under the employment conditions that prevail during the normal period.

\[
LF, K = P, K \times LPF
\]

\[
LPF = 0.35
\]

\[
LF = \text{LABOR FORCE (PERSONS)}
\]

\[
P = \text{POPULATION (PERSONS)}
\]

\[
LPF = \text{LABOR-PARTICIPATION FRACTION (DIMENSIONLESS)}
\]

The labor force LF is a relatively simple measure of the number of people available for employment. The actual number of people desiring employment at any given time depends not only on the population P but also on the ease of obtaining employment, on the aggregate financial status of the households that make up the local population, and on the availability of alternative income sources such as welfare and unemployment benefits. More sophisticated measures of labor availability can reach closer statistical agreement with the actual number of people in the labor force LF (see exercises 5-10 and 5-11).

The purpose of the POPBSN model, however, is not to replicate statistics but to show the connections between business structures BS and population P. Any definition of the labor force LF that allows the feedback loops in Figure 5-1 to operate is adequate for the purposes of the POPBSN model. In the very simple
definition above, the labor force LF is proportional to the population P, so the upper feedback loop in Figure 5-1 can operate. Suppose the population P rises: the labor force LF and the labor-force-to-job ratio LFJR also rise, the diminished job availability causes in-migration IM to decline, and the reduced in-migration IM tends to retard further increases in the population P. The upper feedback loop in Figure 5-1 operates as a brake to unlimited population growth.

**Jobs J.** As discussed in Chapters 1 through 3, the business structures BS variable represents the urban economic base, including both the public sector and the private sector. The larger the economic base (as represented by BS), the larger the number of employees required to operate the economy (for a given level of technology. The jobs J variable in equation 17 is therefore defined as the product of business structures BS and jobs per business structure JBS (the number of jobs an average business structure would contain under normal conditions). In keeping with the simple structure of the POPBSN model, JBS is assumed to be constant.

\[
J = BS \times JBS
\]

\[JBS = \text{JOBS} \times \frac{\text{BUSINESS STRUCTURES (UNITS)}}{\text{JOBS/UNIT}}\]

Under varying economic conditions, jobs J would not necessarily correspond exactly to the actual number of employment positions available in the urban area. Given a labor shortage, for example, businesses might profit by using a machine and employing only two skilled persons at relatively higher wages to perform the same work that three persons would do under normal conditions of labor.

However, the simplest depiction of labor supply and demand rate is depicted in Figure 5-1, and the lower feedback loops regulate the number of business structures. When a labor surplus exists, it stimulates business construction of new structures BS. A greater number of jobs J and thus reduces the labor-to-job ratio in Figure 5-1 regulates the labor force balance the size of the labor force LF.